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Omaha District

2007 Report

Water Quality Conditions in the Missouri River Mainstem System

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2007 Report

Water Quality Conditions in the Missouri River Mainstem System

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June 2008

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

Page

List of Tables

Page

List of Tables (Continued)

Page

List of Figures

Page

List of Plates

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

List of Plates (Continued)

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

List of Plates (Continued)

Page

List of Plates (Continued)

List of Plates (Continued)

Page

List of Plates (Continued)

Page

List of Plates (Continued)

Page

EXECUTIVE SUMMARY

Omaha District Water Quality Management Program

The Omaha District (District) of the U.S. Army Corps of Engineers (Corps) is implementing a Water Quality Management Program (WQMP) as part of the operation and maintenance activities associated with managing the Corps' civil works projects in the District. The WQMP addresses surface water quality management issues and adheres to the guidance and requirements specified in the Corps' Engineering Regulation – ER 1110-2-8154, "Water Quality and Environmental Management for Corps Civil Works Projects" (USACE, 1995).

The annual report of water quality conditions in the Missouri River Mainstem System (Mainstem System) is prepared to document and assess water quality conditions occurring at the Corps' Mainstem System projects in the District. The report describes existing water quality conditions and identifies any evident surface water quality management concerns. The annual reporting of Mainstem System project water quality conditions is done to facilitate water quality management decisions regarding the operation and regulation of the Mainstem System projects.

General Water Quality Concerns in the Omaha District

The following general water quality concerns have been identified for civil works projects in the District: 1) reservoir eutrophication and hypolimnetic dissolved oxygen depletion, 2) sedimentation, 3) shoreline erosion, 4) bioaccumulation of contaminants in aquatic organisms, 5) occurrence of pesticides, and 6) urbanization.

Prioritization of District-Wide Water Quality Management Issues

The District has identified seven priority issues for water quality management; these priority issues and their relative ranking are listed in Table 1.2.

Summary of Project-Specific TMDL Considerations, Fish Consumption Advisories, and Other Water Quality Management Issues

Table 1.3 summarizes TMDL considerations, fish consumption advisories, and other water quality management issues applicable to the Mainstem System projects. The impaired uses and pollutant/stressors (i.e., TMDL considerations) and identified contamination (i.e., Fish Consumption Advisories) identified in Table 1.3 are taken directly from the latest State 303(d) impaired waters listings and issued fish consumption advisories. They are provided for information purposes and are not based on water quality monitoring conducted by the District. The listed other water quality management issues in Table 1.3 were identified by the District based on water quality monitoring and USACE water quality management concerns. Water quality management issues at specific Mainstem System projects will be assessed in further detail in Project Specific Reports (USACE, 2008a) that will be prepared for the project by the District.

Limnological Processes in Reservoirs

The Mainstem System projects in the District involve the operation and maintenance of reservoirs and the regulation of flows discharged from the reservoirs. Much of the water quality monitoring conducted by the District is done to determine existing water quality conditions and identify water quality

management concerns at these reservoirs. A basic understanding of the limnological processes that occur in reservoirs is needed to interpret the water quality information provided in this report. Chapter 2 of this report provides a basic overview of limnological processes that occur in reservoirs.

Water Quality Monitoring at the Mainstem System Reservoirs

Long-term, fixed-station ambient water quality monitoring has occurred at the six Mainstem System reservoirs (i.e., Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point) for the past 30 years. Recent ambient monitoring conducted by the District at the Mainstem System reservoirs included monthly (i.e., May through September) water quality monitoring at a near-dam, deepwater site. At Garrison and Fort Peck Reservoirs, additional long-term ambient sites were respectively added in 2006 and 2007. Water quality monitoring included field measurements and collection of depth-discrete water samples for laboratory analysis.

The District has monitored bacteria levels present at swimming beaches at the Gavins Point Project over the past 5 years. Five swimming beaches on Gavins Point Reservoir and one on Lake Yankton were monitored. Weekly grab samples were collected from May through September and analyzed for fecal coliform and *E. coli* bacteria.

Intensive water-quality surveys have recently been completed or are ongoing at all the Mainstem System projects. A 3-year intensive water-quality survey was completed at the Garrison Project in 2005, the Fort Peck Project in 2006, and the Oahe Project in 2007. Intensive surveys are currently ongoing at the Big Bend, Fort Randall, and Gavins Point Projects. The monitoring objectives of the intensive surveys are to collect water quality data to spatially describe water quality conditions present in the reservoirs during the late spring and summer, and to collect information to facilitate the application of the CE-QUAL-W2 hydrodynamic and water quality model.

Water Quality Monitoring at the Mainstem System Powerplants

As part of the operation of the Mainstem System powerplants, water is drawn from the intake structure of each dam and piped through the powerplant in a "raw water" supply line that is tapped for various uses. The "raw water" supply line is an open ended, flow-through system (i.e., water is continually discharged). A monitoring station, that measures water quality conditions of water drawn from near the start of the "raw water" supply line, has been irregularly maintained at each of the powerplants over the past several years. Recent water quality monitoring has consisted of year-round, hourly measurements of temperature, dissolved oxygen, and conductivity through the use of a data-logger. Monthly grab samples (year-round) have also been collected and analyzed. The water quality conditions measured in the "raw water" supply lines of the powerplants are believed to represent the water quality conditions present in the reservoirs near the dam intakes and in the tailwaters (i.e., Missouri River) immediately downstream of the dam.

Water Quality Monitoring of the Missouri River from Fort Randall Dam to Rulo, Nebraska

Since 2003, the District has cooperated with the Nebraska Department of Environmental Quality to monitor ambient water quality conditions along the Missouri River from Fort Randall Dam to Rulo, Nebraska. Fixed-station monitoring has occurred at the following nine sites: Fort Randall Dam tailwaters; near Verdel, NE; Gavins Point Dam tailwaters; near Maskell, NE; near Ponca, NE; at Decatur, NE; at Omaha, NE; at Nebraska City, NE; and at Rulo, NE. Water quality monitoring consisted of taking field measurements and collecting near-surface grab samples monthly from October through March and biweekly from April through September. The collected grab samples were analyzed for various parameters.

Water Quality Monitoring at the Mainstem System Ancillary Lakes

Lake Yankton, Lake Pocasse, and Lake Audubon are ancillary lakes to the Mainstem System reservoirs respectively at the Gavins Point, Oahe, and Garrison Projects. Water quality monitoring at these three lakes has been irregular in the past. The District initiated ambient water quality monitoring at the lakes in 2006 as part of a 3-year rotational monitoring cycle. However, low-water conditions prevented boat access and therefore prevented water quality monitoring at Lake Pocasse. Monitoring included monthly sampling (May through September) at a near-dam deepwater location and included field measurements for depth profiling and water transparency and collection of near-surface and near-bottom water samples for laboratory analysis.

Water Quality Assessment Methods

For the purposes of this report, existing water quality is defined as water quality conditions that occurred during the past 5 years (i.e., 2003 through 2007). Water quality monitoring conducted during that period was used to describe existing water quality conditions.

Statistical analyses were performed on the water quality monitoring data collected at the Mainstem System reservoirs (including inflow and outflow sites), powerplants, on the Missouri River, and at the mainstem ancillary lakes. Descriptive statistics were calculated to describe central tendencies and the range of observations in existing water quality. Monitoring results were compared to applicable water quality standards criteria established by the appropriate States pursuant to the Federal Clean Water Act.

Longitudinal contour plots were constructed when adequate depth-profile measurements were collected along the length of a reservoir. Adequate information was collected in 2007 to construct longitudinal contour plots at four Mainstem System reservoirs: Fort Peck, Garrison, Oahe, and Fort Randall. At these reservoirs longitudinal contour plots were constructed for water temperature, dissolved oxygen, and turbidity.

Longitudinal box plots were constructed when adequate measurements were collected along the length of a waterbody. Adequate information was collected to construct longitudinal box plots of existing water quality conditions at four Mainstem System reservoirs: Fort Peck, Garrison, Oahe, and Fort Randall; and the lower Missouri River.

Depending on their bathymetry, lakes can experience thermally-induced density stratification in the summer. This can lead to significant vertical water quality variation if anoxic or near-anoxic conditions develop in the hypolimnion. Measured water temperature and dissolved oxygen depth profiles were plotted at the Mainstem System reservoirs and mainstem ancillary lakes. The plotted depth profiles were measured at a near-dam, deepwater ambient monitoring location. Depth profiles measured in the summer months over the past 5 years were plotted. The plots were reviewed to assess the occurrence of thermal stratification and hypolimnetic dissolved oxygen degradation.

The variation of selected parameters with depth was evaluated by comparing near-surface and near-bottom collected samples collected at the Mainstem System reservoirs and ancillary lakes. The compared samples were collected at the near-dam, deepwater monitoring location over the past 5 years. The parameters compared included water temperature, dissolved oxygen, and various nutrients.

Annual seasonal time series plots of water temperatures measured in the Missouri River immediately upstream and downstream of the Mainstem System reservoirs were constructed to display

temporal variation. Time series plots were also prepared for water quality conditions monitored at the Mainstem System powerplants during 2005, 2006, and 2007. Hourly water temperature, dissolved oxygen, and dam discharge were plotted semi-annually for the 3 years.

A lake Trophic State Index (TSI) was calculated from Secchi depth transparency, total phosphorus, and chlorophyll *a* measurements. Values for these three parameters were converted to an index number ranging from 0 to 100. This index value was used to determine the lake's trophic status in accordance with Table 4.1.

The phytoplankton community at the Mainstem System reservoirs was assessed based on collected grab samples. Laboratory analyses consisted of identification of phytoplankton taxa to the lowest practical level and quantification of taxa biovolume. These results were used to determine the relative abundance of phytoplankton taxa at the division level based on the measured biovolumes.

Surface water quality trends at the Mainstem System reservoirs were assessed by evaluating water clarity (i.e. Secchi depth), total phosphorus, chlorophyll *a*, and trophic state index values from monitoring results obtained at long-term, fixed-station ambient monitoring sites for the period 1980 to 2007.

The attainment of water quality standards was assessed by determining the support of designated water quality beneficial uses. Where applicable water quality standards criteria existed, beneficial support was determined by the number of times the criteria were exceeded during the 5-year period of 2003 through 2007 based on water quality monitoring conducted by the District.

<u>Water Quality Conditions Monitored at the Mainstem System Projects</u>

Fort Peck

Monitoring of the existing water quality conditions of Fort Peck Reservoir indicated no significant water quality concerns. On a few occasions measured dissolved oxygen concentrations were below the water quality standards criterion of 5 mg/l. The measured low dissolved oxygen concentrations occurred in the hypolimnion near the reservoir bottom during the later part of the summer thermal stratification period. Water temperature, dissolved oxygen, and turbidity in Fort Peck Reservoir vary temporally, longitudinally from the dam to the reservoir's upper reaches, and vertically from the reservoir's surface to the bottom (Plates 7-20). During the summer, a thermocline typically becomes established in the reservoir at a depth of about 20 meters. The only parameter that significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location was water temperature. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Fort Peck Reservoir exhibited slightly decreasing transparency, slightly increasing levels of total phosphorus, and no observable trend in chlorophyll *a* levels. Monitoring indicated that the lacustrine zone of Fort Peck Reservoir has remained in a mesotrophic state.

Water quality monitoring of the existing conditions of the Fort Peck Dam discharge did not indicate any water quality standards attainment concerns. There appeared to be little correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 30-45). Inflow temperatures of the Missouri River to Fort Peck Reservoir are generally warmer than the outflow temperatures of Fort Peck Dam during March through August and cooler than the outflow temperatures during September through February. A maximum temperature difference occurs in the summer when the Missouri River inflow temperature is about 10°C warmer than the Fort Peck Dam outflow temperature. Colder water temperatures and lower turbidity levels, attributed to the regulation of Fort Peck Dam, are believed to be impacting the endangered pallid sturgeon population in the Missouri River downstream of the dam.

Garrison

Monitoring of the existing water quality conditions of Garrison Reservoir indicated possible water quality concerns regarding water temperature for the support of optimal coldwater habitat and dissolved oxygen levels for the support of aquatic biota. Water temperatures in the epilimnion of the reservoir regularly exceed 15°C in the summer, while temperatures in the hypolimnion are less than 15°C. Dissolved oxygen levels in the hypolimnion continually degrade along the reservoir bottom as summer progresses, and fall below 5.0 mg/l in late summer. Low dissolved oxygen conditions occur in the upstream reaches of the hypolimnion first and progress towards the dam. As the summer progresses, low dissolved oxygen conditions move up from the reservoir bottom into the mid- and upper reaches of the hypolimnion. This pinching off of coldwater habitat threatens the occurrence of optimal coldwater habitat in Garrison Reservoir, especially under low pool levels during drought conditions.

Water temperature, dissolved oxygen, and turbidity in Garrison Reservoir vary temporally, longitudinally from the dam to the reservoir's upper reaches, and vertically from the reservoir's surface to the bottom (Plates 60-79). During the summer, a thermocline typically becomes established in the reservoir at a depth of about 25 meters. The only parameter that significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location was water temperature. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Garrison Reservoir exhibited slightly increasing concentrations of total phosphorus, slightly decreasing levels of chlorophyll *a*, and no observable trend in transparency. Monitoring indicated that the lacustrine zone of Garrison Reservoir is currently in a mesotrophic state and shows no observable trend of an increasing trophic state.

Water quality monitoring of the existing conditions of the Garrison Dam discharge did not indicate any significant water quality concerns. There is a significant correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations during the summer thermal stratification period of Garrison Reservoir (Plates 91-110). This indicates that the vertical extent of the withdrawal zone in the reservoir is dependent upon the discharge rate of the dam. This is believed to be a result of the design of the intake structure (i.e., bottom withdrawal) and the presence of the submerged intake channel leading to the intake structure. Water is likely drawn from an extended vertical zone in Garrison Reservoir year-round, but is only evident in the temperatures monitored at the powerhouse during reservoir thermal stratification during the summer. Inflow temperatures of the Missouri River to Garrison Reservoir are generally warmer than the outflow temperatures of Garrison Dam during April through September and cooler than the outflow temperatures during October through March. A maximum temperature difference occurs in the summer when the Missouri River inflow temperature is about 10°C warmer than the Garrison Dam outflow temperature.

As drought conditions persisted in early 2005, water levels in Garrison Reservoir had fallen to a record low pool elevation of 1805.8 ft-msl on May 12, 2005. At that time it was felt that, unless emergency water quality management measures were implemented in 2005 to preserve the coldwater habitat in the reservoir, the recreational sport fishery would likely be adversely impacted. The reduction of coldwater habitat is exacerbated by withdrawals through the Garrison Dam intake structure. Because the invert elevation of the intake portals to the Garrison Dam power tunnels (i.e., penstocks) is 2 feet above the reservoir bottom, water drawn through the penstocks comes largely from the lower depths of the reservoir. Thus, during the summer thermal-stratification period, water is largely drawn from the hypolimnetic volume of Garrison Reservoir. Three short-term water quality management measures were identified for implementation in 2005 in an effort to preserve the coldwater habitat in the reservoir. These measures, which were implemented at Garrison Dam, included: 1) application of a plywood barrier to the dam's intake trash racks, 2) utilization of head gates to restrict the opening to the dam's power tunnels, and 3) modification of the daily flow cycle and minimum flow releases from the dam. The three

implemented water quality management measures were targeted at drawing water into the dam from higher elevations within Garrison Reservoir. It is estimated the implementation of these short-term water quality management measures resulted in a potential saving of optimal coldwater habitat in Garrison Reservoir of about 379,390 acre-ft in 2005, about 1,021,150 acre-ft in 2006, and about 827,928 acre-ft in 2007.

Oahe

Monitoring of the existing water quality conditions of Oahe Reservoir indicated possible water quality concerns regarding water temperature, dissolved oxygen, and pH for the support of coldwater permanent fish life propagation. Water temperatures in the epilimnion of the reservoir regularly exceed the criterion of 18.3°C in the summer, while temperatures in the hypolimnion are less than 18.3°C. Dissolved oxygen levels in the hypolimnion continually degrade along the reservoir bottom as summer progresses and fall below the criterion of 7 mg/l in late summer. Dissolved oxygen levels did not fall below the criterion of 6 mg/l in the hypolimnion in the area of the reservoir near Oahe Dam. Dissolved oxygen concentrations regularly fall below 6 mg/l in the middle and upstream reaches of the hypolimnion. As the summer progresses, conditions of lower dissolved oxygen move up from the reservoir bottom into the lower reaches of the hypolimnion. No measured pH values were below the lower pH criterion of 6.6. The upper pH criterion of 8.6 was exceeded throughout the reservoir; however, no measured pH values were above 9.

Water temperature, dissolved oxygen, and turbidity in Oahe Reservoir vary temporally, longitudinally from the dam to the reservoir's upper reaches, and vertically from the reservoir's surface to the bottom (Plates 130-144). During the summer, a thermocline typically becomes established in the reservoir at a depth of about 20 meters. The only parameter that significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location was water temperature. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Oahe Reservoir exhibited slightly increasing concentrations of total phosphorus and no observable trends in transparency or chlorophyll *a*. Monitoring indicated that the lacustrine zone of Oahe Reservoir is currently in a mesotrophic state and shows no observable trend of an increasing trophic state.

Water quality monitoring of the existing conditions of the Oahe Dam discharge indicated possible water quality concerns regarding temperature and dissolved oxygen for the support of coldwater permanent fish life propagation. Temperatures of the water passed through Oahe Dam in the summer regularly exceeded the temperature criterion of 18.3°C. During the summer when Oahe Reservoir is thermally stratified, water temperatures in the epilimnion of the reservoir exceed 18.3°C, while temperatures in the hypolimnion are less than 18.3°C. Water discharged through Oahe Dam for power production is withdrawn from Oahe Reservoir at elevation 1525 ft-msl, approximately 110 feet above the reservoir bottom. Thus, water withdrawn from the reservoir in the summer comes largely from the epilimnion, especially when pool elevations are lower due to drought conditions. Because water passed through Oahe Dam during the summer is withdrawn from the epilimnion of the reservoir, the temperature criterion of 18.3°C for the Missouri River and Big Bend Reservoir just downstream of the dam are not being met during the summer when Oahe Reservoir is thermally stratified. Generally, dissolved oxygen levels were below 7 mg/l from mid July through September. Seemingly, the lower dissolved oxygen levels may be related to lower oxygen solubility with warmer water and possible oxygen degradation in the hypolimnion during late summer.

There appeared to be little correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 157 - 172). Inflow temperatures of the Missouri River to Oahe Reservoir are generally warmer than the outflow temperatures of the Oahe Dam discharge

during the period of April through June. Outflow temperatures of the Oahe Dam discharge are generally warmer than the inflow temperatures of the Missouri River during the period of July through March. A maximum temperature difference occurs in the fall when the Oahe Dam discharge temperature is about 4°C warmer than the Missouri River inflow temperature.

Big Bend

Water quality monitoring of the existing conditions of Big Bend Reservoir indicated possible water quality concerns regarding water temperature, dissolved oxygen, and pH for the support of coldwater permanent fish life propagation. Based on the criteria for the protection of coldwater permanent fish life propagation, 66% of the observations exceeded water temperature criteria, 4 to 19% of the observations did not meet dissolved oxygen criteria, and 27% of the observations exceeded the pH criteria. It is noted that, if Big Bend Reservoir were classified for the protection of warmwater permanent fish propagation instead of coldwater, no observations would have exceeded the pH criteria and less than 1% of the observations would not have met the water temperature and dissolved oxygen criteria for warmwater permanent fish propagation. Ambient summer water temperatures in Big Bend Reservoir do not appear to be cold enough to support coldwater permanent fish life propagation as defined by State water quality criteria. Consideration should be given to reclassify the reservoir for a warmwater permanent fish life propagation use based on a use attainability assessment of "natural conditions" regarding ambient water temperatures.

Big Bend Reservoir does not typically exhibit summer thermal stratification due to its shallower depth and the high discharge rates that occur through Big Bend Dam. No parameter significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Big Bend Reservoir exhibited slightly increasing concentrations of total phosphorus and decreasing levels of transparency and chlorophyll *a*. Monitoring indicated that the lacustrine zone of Big Bend Reservoir is currently in a mesotrophic to moderately eutrophic state and shows little observable trend of an increasing trophic state.

Monitoring of the existing water quality conditions of the Big Bend Dam discharge did not indicate any water quality concerns. There appeared to be only minor correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 187 - 202). Inflow temperatures of the Missouri River to Big Bend Reservoir are about 2°C warmer than the outflow temperatures of Big Bend Dam during the winter. Temperatures of the Big Bend Dam discharge are about 1-2°C warmer than the inflow temperatures of the Missouri River during the spring, summer, and fall.

Fort Randall

Monitoring of the existing water quality conditions of Fort Randall Reservoir indicated possible water quality concerns regarding suspended solids for the support of warmwater permanent fish life propagation. The chronic suspended solids criterion was exceeded in Fort Randall Reservoir in the area near the confluence of the White River.

Water temperature, dissolved oxygen, and turbidity in Fort Randall Reservoir vary temporally, longitudinally from the dam to the reservoir's upper reaches, and vertically from the reservoir's surface to the bottom (Plates 213-227). During the summer, a thermocline typically becomes established in the reservoir at a depth of about 25 meters. No parameter significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Fort Randall Reservoir exhibited decreasing

levels of transparency and chlorophyll *a* and on observable trend in total phosphorus. Monitoring indicated that the lacustrine zone of Fort Randall Reservoir is currently in a mesotrophic state and shows no observable trend of a changing trophic state.

Water quality monitoring of the existing conditions of the Fort Randall Dam discharge indicated no water quality concerns. There is a significant correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations during the summer thermal stratification period of Fort Randall Reservoir (Plates 238-253). This indicates that the vertical extent of the withdrawal zone in the reservoir is dependent upon the discharge rate of the dam. This is believed to be a result of the design of the intake structure (i.e., bottom withdrawal) and the presence of the submerged approach channel leading to the intake structure. Water is likely drawn from an extended vertical zone in Fort Randall Reservoir year-round, but is only evident in the temperatures monitored at the powerhouse during reservoir thermal stratification during the summer.

Inflow temperatures of the Missouri River to Fort Randall tend to be at little warmer than the outflow temperatures of Fort Randall Dam during the spring and early summer. Outflow temperatures of the Fort Randall Dam discharge tend to be a little warmer than the Missouri River inflow temperatures in the late-summer and fall.

Gavins Point

Water quality monitoring of the existing conditions of Gavins Point Reservoir indicated a possible water quality concern regarding dissolved oxygen for the support of warmwater aquatic life. Based on the criteria for the protection of warmwater aquatic life, 8% of the observations did not meet dissolved oxygen criteria. The dissolved oxygen measurements that were below the 5 mg/l criterion occurred near the reservoir bottom in the hypolimnion during the summer on occasions when the reservoir was thermally stratified.

During periods of calm weather in the summer, Gavins Point Reservoir will develop a slight thermal stratification. When this slight stratification occurs, a thermocline is present at about 8 meters depth. This indicates the reservoir is probably polymixic. The thermal stratification breaks down under windier conditions, given the shallow depth of the reservoir (i.e., 14 meters), and the reservoir mixes throughout its water column. No parameter significantly varied from the surface to the bottom of the reservoir at the near-dam, deepwater location. The dominant algal group sampled in the reservoir was Bacillariophyta (i.e., Diatoms). Over the past 28 years, Gavins Point Reservoir exhibited slightly increasing concentrations of total phosphorus and decreasing levels of transparency and chlorophyll *a*. Monitoring indicated that the lacustrine zone of Gavins Point Reservoir is currently in a moderately eutrophic to eutrophic state and shows no observable trend of a changing trophic state.

Water quality monitoring of the existing conditions of the Gavins Point Dam discharge did not indicate any water quality concerns. There appeared to be little correlation between dam discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 277-292). Inflow temperatures of the Missouri River to Gavins Point Reservoir tend to be at little cooler than the outflow temperatures of Gavins Point Dam during the spring and early summer. Outflow temperatures of the Gavins Point Dam discharge tend to be a little warmer than the Missouri River inflow temperatures in the late-summer and fall.

Comparison of Water Quality Conditions at the Mainstem Reservoirs

A comparison of existing water quality conditions monitored at the Mainstem System reservoirs is provided in Tables 5.22 and 5.23.

Lower Missouri River

Monitoring of the existing water quality conditions of the lower Missouri River from Gavins Point Dam to Rulo, Nebraska indicated no water quality concerns. Longitudinal variation in selected water quality parameters was assessed with box plots arranged relative to their respective locations along the Missouri River (Plate 309). Parameters that exhibited no observable longitudinal trend included pH, specific conductance, and total ammonia. Parameters that slightly decreased in a downstream direction included dissolved oxygen. Parameters that slightly increased in a downstream direction included water temperature, chloride, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, atrazine, and metolachlor. Parameters that greatly increased in downstream direction included turbidity, total suspended solids, nitrate-nitrite nitrogen, and total phosphorus.

Mainstem Ancillary Lakes

Monitoring of existing water quality conditions at Lakes Audubon and Yankton indicated no major water quality concerns.

Water Quality Monitoring and Management Activities Planned for Future Years

A tentative schedule of water quality monitoring targeted for implementation over the next 5 years is given in Table 8.1. The identified data collection activities are considered the minimum needed to allow for the annual assessment of water quality conditions at District projects, and the preparation of project-specific water quality reports and water quality management objectives for the Mainstem System Projects. The actual monitoring activities that are implemented will be dependent upon the availability of future resources.

The CE-QUAL-W2 hydrodynamic and water quality model is being applied to facilitate the development project-specific water quality reports and project-specific water quality management objectives. The tentative schedule for implementing these water-quality management planning activities on the Mainstem System projects is given in Table 8.2.

1 INTRODUCTION

1.1 OMAHA DISTRICT WATER QUALITY MANAGEMENT PROGRAM

The Omaha District (District) of the U.S. Army Corps of Engineers (Corps) is implementing a Water Quality Management Program (WQMP) as part of the operation and maintenance activities associated with managing the Corps' civil works projects in the District. The WQMP addresses surface water quality management issues and adheres to the guidance and requirements specified in the Corps' Engineering Regulation – ER 1110-2-8154, "Water Quality and Environmental Management for Corps Civil Works Projects" (USACE, 1995). The following four goals have been established for the District's WQMP (USACE, 2008a):

1) Ensure that surface water quality, as affected by District projects and their regulation, is suitable for project purposes, existing water uses, and public health and safety, and is in compliance with applicable Federal, Tribal, and State water quality standards.
2) Establish and maintain a surface water quality monitoring and data evaluation program that facilitates the achievement of water quality management objectives, allows for the characterization of water quality conditions, and defines the influence of District projects on surface water quality.
3) Establish and maintain strong working partnerships and collaboration with appropriate entities within and outside the Corps regarding surface water quality management at District projects.
4) Document the water quality management activities of the District's Water Quality Management Program and Project surface water quality conditions to record trends, identify problems and accomplishments, and provide guidance to program and project managers.

Water quality data collection and assessment are of paramount importance to the implementation of the District's WQMP.

The reporting of water quality conditions is done to document and assess water quality conditions occurring at Corps civil works projects in the District. This report describes existing and historic water quality conditions and identifies any evident surface water quality management issues. The reporting of water quality conditions is done to facilitate water quality management decisions regarding the operation and regulation of Corps projects.

1.2 CORPS CIVIL WORKS PROJECTS WITHIN THE OMAHA DISTRICT

The location of Corps' Missouri River Mainstem System (Mainstem System) civil works project areas within the District and background information on the projects are provided in Figure 1.1 and Table 1.1. These are the Mainstem System civil works projects under the purview of the District's WQMP.

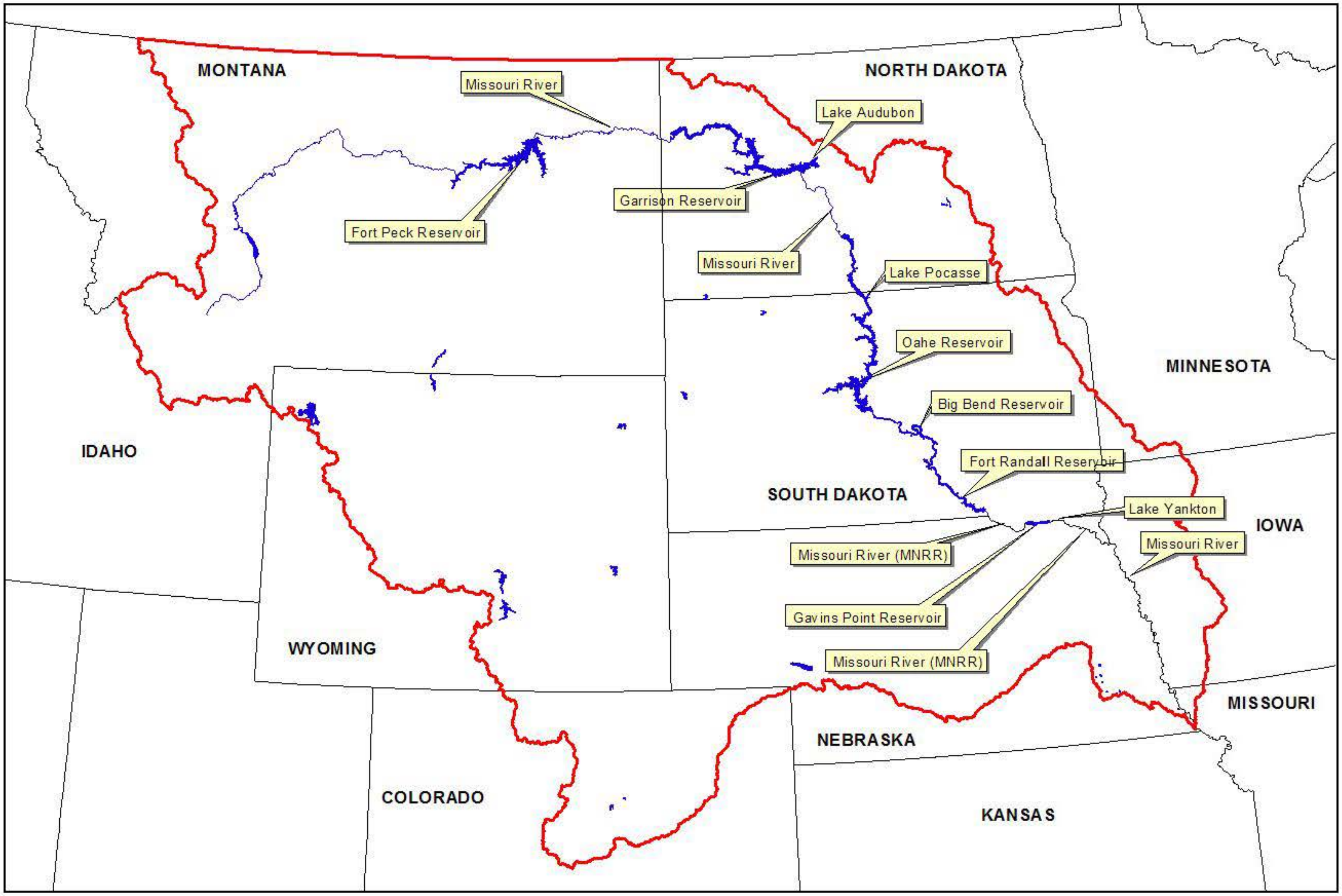

Figure 1.1. Missouri River Mainstem System civil works projects in the Omaha District. (Refer to Table 1.1 for project information.)

Table 1.1. Background information for Corps Missouri River Mainstem System project areas located in the Omaha District**.**

Project Area	Location	Dam Closure	Lake Size or River Length(1)	Authorized Proposes(2)	Water Quality Designated Beneficial Uses(3)
MAINSTEM RESERVOIRS					
Fort Peck (Fort Peck Lake)	Fort Peck, MT	1937	246,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(4)	Rec, FW, WAL, DWS, IWS, AWS
Garrison (Lake Sakakawea)	Garrison, ND	1953	380,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(5)	Rec, FW, CAL, DWS, IWS, AWS
Oahe (Lake Oahe)	Pierre, SD	1958	374,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(4)	Rec, FW, CAL, DWS, IWS, AWS
Big Bend (Lake Sharpe)	Chamberlain, SD	1963	61,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(4)	Rec, FW, CAL, DWS, IWS, AWS
Fort Randall (Lake Francis Case)	Pickstown, SD	1952	102,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(4)	Rec, FW, WAL, DWS, IWS, AWS
Gavins Point (Lewis and Clark Lake)	Yankton, SD	1955	31,000 A (mp)	FC, Rec, FW, HP, WS, WQ, Nav, Irrig(4)	Rec, FW, WAL, DWS, IWS, AWS, Aes
MAINSTEM RESERVOIR ANCILLARY LAKES					
Lake Audubon (Garrison Project – Snake Creek Dam)	Garrison, ND	1952	18,780 A (mp)	Rec, FW	Rec, FW, WAL, DWS, IWS, AWS
Lake Pocasse (Oahe Project – Spring Creek Dam)	Pollock, SD	1961	1,545 A (mp)	FW	Rec, FW, WAL, AWS
Lake Yankton (Gavins Point Project)	Yankton, SD	1955	250 A	Rec, FW	Rec, WAL, AWS, Aes
MISSOURI RIVER					
Fort Peck Reach	Fort Peck Dam to Garrison Reservoir	---	204 M	----	Rec, FW, CAL, WAL, DWS, IWS, AWS
Garrison Reach	Garrison Dam to Oahe Reservoir	---	87 M	---	Rec, FW, WAL, DWS, IWS, AWS
Oahe Reach	Oahe Dam to Big Bend Reservoir	---	5 M	---	Rec, FW, CAL, DWS, IWS, AWS
Fort Randall Reach	Fort Randall Dam to Gavins Point Reservoir	---	39 M	National Recreational River(6)	Rec, FW, WAL, DWS, IWS, AWS, Aes, OSRW
Gavins Point Reach	Gavins Point Dam to Ponca, NE	---	59 M	National Recreational River(6)	Rec, FW, WAL, DWS, IWS, AWS, Aes, OSRW
Kensler's Bend Reach	Ponca, NE to Sioux City, IA	---	17 M	---	Rec, FW, WAL, DWS, IWS, AWS, Aes, OSRW
Lower Missouri River Reach	Sioux City, IA to Rulo, NE	---	237 M	BS, Nav	Rec, FW, WAL, DWS, IWS, AWS, Aes

(1) A = acres, M = miles, mp = top of multipurpose pool, cp = top of conservation pool.

(2) Purposes authorized under Federal laws for the operation of the Corps projects.

FC = Flood Control, Rec = Recreation, FW = Fish & Wildlife, HP = Hydroelectric Power, WS = Water Supply, WQ = Water Quality, Nav = Navigation, Irrig = Irrigation, BS = Bank Stabilization.

(3) Water quality dependent beneficial uses designated to the water body in State water quality standards pursuant to the Federal Clean Water Act.

Rec = Recreation, FW = Fish and Wildlife, WAL, Warmwater Aquatic Life, CAL = Coldwater Aquatic Life, DWS = Domestic Water Supply, IWS = Industrial Water Supply, AWS = Agricultural Water Supply, Aes = Aesthetics, OSRW = Outstanding State Resource Water.

(4) Section 8 (PL 78-534) Federal irrigation has not been developed at this project; however, water is being withdrawn for private irrigation use.

(5) There is a Section 8 Federal irrigation project authorized at this project, but it is not yet operational; however, water is being withdrawn for private irrigation use.

(6) Designated a Recreational River under the Federal Wild and Scenic Rivers Act.

1.3 WATER QUALITY MONITORING GOALS AND OBJECTIVES

The District has established purposes and monitoring objectives for surface water quality monitoring under its WQMP. These monitoring purposes and objectives were established to meet the water quality information needs of the WQMP and the water quality management objectives, data collection rules and objectives, data application guidance, and reporting requirements identified in ER 1110-2-8154. Pertinent monitoring goals and objectives that have been established are:

Purpose 1: Determine surface water quality conditions at District projects.

Monitoring Objectives:

- For new District water resource projects, establish baseline surface water quality conditions as soon as possible and appropriate.
- Characterize the spatial and temporal distribution of surface water quality conditions at District projects.
- Identify pollutants and their sources that are affecting surface water quality and the aquatic environment at District projects.
- Evaluate water/sediment interactions and their effects on overall surface water quality at District projects.
- Identify the presence and concentrations of contaminants in indicator and human-consumed fish species at District projects.
- Investigate, as necessary, unique events (e.g., fish kills, hazardous waste spills, operational emergencies, health emergencies, public complaints, etc.) at District projects that may have degraded surface water quality or indicate the aquatic environment has been impacted.

Purpose 2: Document surface water quality concerns that are due to the operation and reservoir regulation of District projects.

Monitoring Objectives:

- Determine if surface water quality conditions at District projects or attributable to District operations or reservoir regulation (i.e., downstream conditions resulting from reservoir discharges) meets applicable Federal, Tribal, and State water quality standards.
- Determine if surface water quality conditions at District projects or attributable to District operations or reservoir regulation are improving, degrading, or staying the same over time.
- Apply water quality models to assess surface water quality conditions at District projects.

Purpose 3: Provide data to support project operations and reservoir regulation for effective management and enhancement of surface water quality and the aquatic environment.

Monitoring Objectives:

- Provide surface water quality data required for real-time regulation of District projects.
- Collect the information needed to design, engineer, and implement measures or modifications at District projects to enhance surface water quality and the aquatic environment.

Purpose 4: Evaluate the effectiveness of structural or regulation measures implemented at District projects to enhance surface water quality and the aquatic environment.

Monitoring Objectives:

- Evaluate the effectiveness of implemented measures at District projects to improve surface water quality and the aquatic environment.

1.4 DATA COLLECTION APPROACHES

Several data collection approaches have been identified by the District for collecting surface water quality data. Pertinent water quality monitoring approaches are:

- Long-term, fixed-station ambient monitoring;
- Intensive surveys;
- Special studies; and

- Investigative monitoring.

Long-term, fixed-station ambient monitoring is intended to provide information that will allow the District to determine the status and trends of surface water quality at District projects. This type of sampling consists of systematically collecting samples at the same location over a long period of time (e.g., collecting monthly water samples at the same site for several years).

Intensive surveys are intended to provide more detailed information regarding surface water quality conditions at District projects. They typically will include more sites sampled over a shorter timeframe than long-term fixed-station monitoring. Intensive surveys will provide the detailed water quality information needed to thoroughly understand surface water quality conditions at a project.

Special studies are conducted to address specific information needs. Special water quality studies may be undertaken to collect the information needed to "scope-out" a specific water quality problem, apply water quality models, design and engineer modifications at projects, or evaluate the effectiveness of implemented water quality management measures.

Investigative monitoring is typically initiated in response to an immediate need for surface water quality information at a District project. This may be in response to an operational situation, the occurrence of a significant pollution event, public complaint, or a report of a fish kill. Any District response to a pollution event or fish kill would need to be coordinated with the appropriate Tribal, State, and Local agencies. The type of sampling that is done for investigative purposes is highly specific to the situation under investigation.

1.5 GENERAL WATER QUALITY CONCERNS IN THE OMAHA DISTRICT

1.5.1 RESERVOIR EUTROPHICATION AND HYPOLIMNETIC DISSOLVED OXYGEN DEPLETION

Reservoirs are commonly classified or grouped by trophic or nutrient status. The natural progression of reservoirs through time is from an oligotrophic (i.e., low nutrient/low productivity) through a mesotrophic (i.e., intermediate nutrient/intermediate productivity) to a eutrophic (i.e., high nutrient/high productivity) condition. The tendency toward the eutrophic or nutrient-rich status is common to all impounded waters. The eutrophication, or enrichment process, can be accelerated by nutrient additions to the reservoir resulting from cultural activities.

As deeper, temperate lakes warm in the spring and summer they typically become thermally stratified, due to the density differences of the water, into three vertical zones: 1) epilimnion, 2) metalimnion, and 3) hypolimnion. The epilimnion is the upper zone of less dense, warmer water in the lake that remains relatively mixed due to wind action and convection. The metalimnion is the middle zone that represents the transition from warm surface water to cooler bottom water. The hypolimnion is the bottom zone of more dense, colder water that is relatively quiescent.

A significant water quality concern that can occur in reservoirs that thermally stratify in the summer is the depletion of dissolved oxygen levels in the hypolimnion. The depletion of dissolved oxygen is attributed to the differing density of water with temperature, the utilization of dissolved oxygen in the decomposition of organic matter, and the oxidation of reduced inorganic substances. When density differences become significant, the deeper colder water is isolated from the surface and re-oxygenation from the atmosphere. In eutrophic lakes, the decomposition of the abundant organic matter can significantly reduce dissolved oxygen in the quiescent hypolimnetic zone. Anoxic conditions in the hypolimnion can result in the release of sediment-bound substances (e.g., phosphorus, metals, sulfides, etc.) as the reduced conditions intensify and result in the production of toxic and caustic substances (e.g.,

hydrogen sulfide, etc.). Most fish and other intolerant aquatic life cannot inhabit water with less than 4 to 5 mg/l dissolved oxygen for extended periods. These conditions can impact aquatic life in the reservoir and also in waters downstream of the reservoir if its releases are from a bottom outlet.

1.5.2 SEDIMENTATION

Sedimentation is a process that reduces the usefulness of reservoirs. In the design and construction of reservoirs, the Corps will commonly allow for additional volume to accommodate sedimentation. The incoming sediment can seriously affect the reservoir ecology, fisheries, and benthic aquatic life. The reservoir can suffer ecological damage before a volume function such as flood control is impacted. The influx of sediment eliminates fish habitat, adds nutrients, destroys aesthetics, and decreases biodiversity. Working closely with the project sponsors in an effort to manage sediment input could ultimately prolong reservoir life. Wetlands or sediment traps could be constructed at the headwaters of a reservoir, either upstream of the reservoir or in a portion of the reservoir's upper end, to trap sediment.

1.5.3 SHORELINE EROSION

Shoreline erosion is a major problem occurring on nearly all reservoirs located in areas of erodible soils such as the Midwest. Over 6,000 miles of reservoir shoreline exist at District projects, and it is estimated that over 70 percent of this shoreline is eroding. Some locations have been protected, such as recreational and archaeological sites, but most of the shoreline continues to erode. Continued loss of the shoreline habitat (littoral zone) results in the loss of fishery habitat as well as loss of habitat for other biota such as aquatic vegetation and benthic invertebrates.

1.5.4 BIOACCUMULATION OF CONTAMINANTS IN AQUATIC ORGANISMS

Bioaccumulation is the accumulation of contaminants in the tissue of organisms through any route, including respiration, ingestion, or direct contact with contaminated water or sediment. Bioavailable, for chemicals, is the state of being potentially available for biological uptake by an aquatic organism when that organism is processing or encountering a given environmental medium (e.g., the chemicals that can be extracted by the gills from the water as it passes through the respiratory cavity or the chemicals that are absorbed by internal membranes as the organism moves through or ingests sediment). In the aquatic environment, a chemical can exist in three different basic forms that affect availability to organisms: 1) dissolved, 2) sorbed to biotic or abiotic components and suspended in the water column or deposited on the bottom, and 3) incorporated (accumulated) into organisms. Bioconcentration is a process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake (e.g., by gill or epithelial tissue) and elimination. Biomagnification is the result of the process of bioconcentration and bioaccumulation by which tissue concentrations of bioaccumulated chemicals increase as the chemical passes up through two or more trophic levels. The term implies an efficient transfer of a chemical from food to consumer so that residual concentrations increase systematically from one trophic level to the next.

Bioaccumulation of contaminants can have a direct effect on aquatic organisms. These effects can be chronic (reduced growth, fecundity, etc.) and acute (lethality). The bioaccumulation of contaminants can also be a concern to human health when the contaminated tissue of aquatic organisms is consumed by humans.

1.5.5 OCCURRENCE OF PESTICIDES

Pesticides are widely applied to lands throughout the District. Pesticides detected at District projects over the past 5 years include: acetochlor, alachlor, atrazine, isopropalin, metolachlor, metribuzin, profluralin, and propazine. Many of these pesticides do not have State or Federal numeric water quality criteria established.

1.5.6 URBANIZATION

Construction methods used to develop urban areas disturb the land and allow sediment-laden runoff to impact nearby streams and lakes. Best management practices (BMPs) to minimize construction-associated sedimentation damages are used ineffectively in many cases. BMPs to control the impact of construction practices include; sediment retention basins, phased "grading", and runoff control (e.g. hay bales, silt fences, vegetative ground cover, terracing, etc). Efforts need to be made to prevent sedimentation from off-project construction activities from causing impacts to District projects. This could be accomplished by the appropriate State, County, or City agencies working with developers.

Post-construction problems are commonly associated with storm drainage and urban pollution. The conversion of grasslands or forests to roads, rooftops, sidewalks, and other water impervious surfaces make stream flows more variable and increase the frequency of high flow events. In addition, pollutants associated with urban drainage can impact downstream water bodies. Storm sewer exits can be allowed on project lands provided detention in the form of ponds, swales, or wetlands exist on private property. A developer may be asked to construct a series of wetlands to slow downhill flows and provide time for bacterial die-off, chemical degradation, reduced flow rates, and sediment settling.

1.6 PRIORITIZATION OF DISTRICT-WIDE WATER QUALITY MANAGEMENT ISSUES

The District has identified seven priority issues for water quality management. These priority issues and their relative ranking are listed in Table 1.2.

Table 1.2. Priority water quality management issues within the Omaha District**.**

Ranking*	Water Quality Management Issue
1	Determine how regulation of the Missouri River Mainstem System (Mainstem System) dams affects water quality in the impounded reservoir and downstream river. Utilize the CE-QUAL-W2 hydrodynamic and water quality model to facilitate this effort.
2	Evaluate how eutrophication is progressing in the Mainstem System reservoirs, especially regarding the expansion of anoxic conditions in the hypolimnion during summer stratification.
3	Determine how flow regimes, especially the release of water from Mainstem System projects, affects water quality in the Missouri River.
4	Provide water quality information to support Corps reservoir regulation elements for effective surface water quality and aquatic habitat management.
5	Provide water quality information and technical support to the Tribes and States in the development of their Section 303(d) lists and development and implementation of TMDLs at District projects.
6	Identify existing and potential surface water quality problems at District projects and develop and implement appropriate solutions.
7	Evaluate surface water quality conditions and trends at District projects.

* 1 = Highest priority, 7 = Lowest Priority

1.7 PROJECT-SPECIFIC WATER QUALITY MANAGEMENT ISSUES AT THE MAINSTEM SYSTEM PROJECTS

1.7.1 SECTION 303(D) LISTINGS OF IMPAIRED WATERS

Under Section 303(d) of the Federal Clean Water Act (CWA), Tribes and States, with the delegated authority from the U.S. Environmental Protection Agency (EPA), are required to prepare a periodic list of impaired waters [i.e., Section 303(d) list]. Impaired waters refer to those water bodies where it has been determined that technology-based effluent limitations required by Section 301 of the CWA are not stringent enough to attain and maintain applicable water quality standards. Tribes and States, as appropriate, are required to establish and implement Total Maximum Daily Loads (TMDLs) for water bodies on their Section 303(d) lists.

1.7.2 FISH CONSUMPTION ADVISORIES

Fish are capable of accumulating many toxic substances in excess of 1,000 times the concentrations found in surface waters. The public has expressed concerns on whether fish caught from District project waters are safe to consume. It is important that answers to public health concerns be based on substantiated knowledge of toxicants in fish fillets and the public health risks associated with measured toxicant concentrations. This type of information can be used by States when considering the issuance of fish consumption advisories. Fish consumption advisories have been issued for fish caught from certain District project waters. Mercury is the most prevalent contaminant leading to the issuance of fish consumption advisories in the District.

1.7.3 SUMMARY OF PROJECT-SPECIFIC TMDL CONSIDERATIONS, FISH CONSUMPTION ADVISORIES, AND OTHER WATER QUALITY MANAGEMENT ISSUES

Table 1.3 summarizes TMDL considerations, fish consumption advisories, and other water quality management issues applicable to the Mainstem System projects. The impaired uses and pollutant/stressors (i.e., TMDL considerations) and identified contamination (i.e., Fish Consumption Advisories) identified in Table 1.3 are taken directly from the appropriate State 303(d) impaired waters listings and issued fish consumption advisories. They are provided for information purposes and are not based on water quality monitoring conducted by the District. The listed other water quality management issues in Table 1.3 were identified by the District based on water quality monitoring and Corps water quality management concerns. Water quality management issues at specific Mainstem System projects will be assessed in detail in Project-Specific Reports (USACE, 2008a) prepared for the project by the District.

Table 1.3. Summary of project-specific water quality management issues and concerns.

Project Area	TMDL Considerations*				Fish Consumption Advisories		Other Water Quality Management Issues
	On 303(d) List	Impaired Uses	Pollutant/Stressor	TMDL Completed	Advisory in Effect	Identified Contamination	
Missouri River Mainstem System Projects:							
Missouri River (Bullwhacker Creek to Fort Peck Reservoir)	Yes	Aquatic Life Drinking Water Supply Warmwater Fishery	Riparian Alteration (AL, WWF) Arsenic (AL, DWS, WWF) Copper (AL, WWF)	No	No	-----	Pallid sturgeon recovery priority area
Fort Peck Reservoir	Yes	Drinking Water Supply Recreation	Lead, Mercury Aquatic Plants – Native	No	Yes	Mercury	
Missouri River (Fort Peck Dam to the Milk River)	Yes	Aquatic Life Coldwater Fishery	Riparian Alteration Flow Alteration Water Temperature	No	No	-----	Pallid sturgeon recovery priority area
Missouri River (Milk River to the Poplar River)	Yes	Aquatic Life Warmwater Fishery	Riparian Alteration Flow Alteration Water Temperature	No	No	-----	Pallid sturgeon recovery priority area
Missouri River (Poplar River to MT/ND State line)	Yes	Aquatic Life Warmwater Fishery	Flow Alteration Water Temperature	No	No	-----	Pallid sturgeon recovery priority area
Garrison Reservoir	Yes	Fish and Other Aquatic Biota Fish Consumption	Low Dissolved Oxygen Water Temperature Methyl-Mercury	No	Yes	Mercury	Hypolimnetic dissolved oxygen
Missouri River (Garrison Dam tailwaters)	No	-----	-----	-----	Yes	Mercury	Low dissolved oxygen in Garrison Dam tailwaters (associated with late summer hypolimnetic reservoir withdrawals)
Lake Pocasse (Oahe Reservoir)	Yes	Warmwater Fishery	Eutrophication	No	No	-----	
Big Bend Reservoir	No	-----	Sediment	Yes	No	-----	TMDL developed for sediment. A nonpoint source management project is being implemented in the Bad River watershed.
Missouri River (Fort Randall Dam to Gavins Point Reservoir)	No	-----	-----	-----	No	-----	National recreational river Pallid sturgeon recovery priority area
Gavins Point Reservoir	No	-----	-----	-----	No	-----	Sedimentation Emergent aquatic vegetation
Missouri River (downstream from Gavins Point Dam)	Yes	Recreation Aquatic Life	Pathogens Dieldrin, PCBs Chlorodibromomethane	No	Yes	Dieldrin PCBs	National recreational river Pallid sturgeon recovery priority area Summer ambient water temperature (NPDES limitations regarding cooling water discharges)
Missouri River (Council Bluffs, IA)	Yes	Drinking Water Supply	Arsenic	No	-----	-----	

* Information taken from published State Total Maximum Daily Load (TMDL) 303(d) reports and listings as of January 1, 2006.

2 LIMNOLOGICAL PROCESSES IN RESERVOIRS

Many of the Corps civil works projects in the District involve the operation and maintenance of a reservoir or the regulation of flows discharged from reservoirs. Much of the water quality monitoring conducted by the District is done to determine existing water quality conditions and identify water quality management concerns at these reservoirs. A basic understanding of the limnological processes that occur in reservoirs is needed to interpret the water quality information provided in this report. The following discussion provides a basic overview of limnological processes that occur in reservoirs.

2.1 VERTICAL AND LONGITUDINAL WATER QUALITY GRADIENTS

The annual temperature distribution represents one of the most important limnological processes occurring within a reservoir. Thermal variation in a reservoir results in temperature-induced density stratification, and an understanding of the thermal regime is essential to water quality assessment. Deep, temperate-zone lakes typically completely mix from the surface to the bottom twice a year (i.e., dimictic). Temperate-zone dimictic lakes exhibit thermally-induced density stratification in the summer and winter months that is separated by periods of "turnover" in the spring and fall. This stratification typically occurs through the interaction of wind and solar insolation at the lake surface and creates density gradients that can influence lake water quality. During the summer, solar insolation has its highest intensity and the reservoir becomes stratified into three zones: 1) epilimnion, 2) metalimnion, and 3) hypolimnion.

<u>Epilimnion</u>: The epilimnion is the upper zone that consists of the less dense, warmer water in the reservoir. It is fairly turbulent since its thickness is determined by the turbulent kinetic energy inputs (e.g., wind, convection, etc.), and a relatively uniform temperature distribution throughout this zone is maintained.

<u>Metalimnion</u>: The metalimnion is the middle zone that represents the transition from warm surface water to colder bottom water. There is a distinct temperature gradient through the metalimnion. The metalimnion contains the thermocline that is the plane or surface of maximum temperature rate change.

<u>Hypolimnion</u>: The hypolimnion is the bottom zone of more dense, colder water that is relatively quiescent. Bottom withdrawal or fluctuating water levels in reservoirs, however, may significantly increase hypolimnetic mixing.

Long, dendritic reservoirs, with tributary inflows located a considerable distance from the outflow and unidirectional flow from headwater to dam develop gradients in space and time (USACE, 1987). Although these gradients are continuous from headwater to dam, three characteristic zones result: a riverine zone, a zone of transition, and a lacustrine zone (USACE, 1987).

<u>Riverine Zone:</u> The riverine zone is relatively narrow, well mixed, and, although water current velocities are decreasing, advective forces are still sufficient to transport significant quantities of suspended particles, such as silts, clays, and organic particulate. Light penetration in this zone is minimal and may be the limiting factor that controls primary productivity in the water column. The decomposition of tributary organic loadings often creates a significant oxygen demand, but an aerobic environment is maintained because the riverine zone is generally shallow and well mixed. Longitudinal dispersion may be an important process in this zone.

<u>Zone of Transition:</u> Significant sedimentation occurs through the transition zone, with a subsequent increase in light penetration. Light penetration may increase gradually or abruptly, depending on the flow regime. At some point within the mixed layer of the zone of transition, a

compensation point between the production and decomposition of organic matter should be reached. Beyond this point, production of organic matter within the reservoir mixed layer should begin to dominate.

Lacustrine Zone: The lacustrine zone is characteristic of a lake system. Sedimentation of inorganic particulate is low. Light penetration is sufficient to promote primary production, with nutrient levels the limiting factor and production of organic matter exceeds decomposition within the mixed layer. Entrainment of metalimnetic and hypolimnetic water, particulate, and nutrients may occur through internal waves or wind mixing during the passage of large weather fronts. Hypolimnetic mixing may be more extensive in reservoirs than "natural" lakes because of bottom withdrawal. In addition, an intake structure may simultaneously remove water from the hypolimnion and metalimnion.

When tributary inflow enters a reservoir, it displaces the reservoir water. If there is no density difference between the inflow and reservoir waters, the inflow will mix with the reservoir water as the inflow water moves toward the dam. However, if there are density differences between the inflow and reservoir waters, the inflow moves as a density current in the form of overflows, interflows, or underflows. Internal mixing is the term used to describe mixing within a reservoir from such factors as wind, Langmuir circulation, convection, Kelvin-Helmholtz instabilities, and outflow (USACE, 1987).

2.2 CHEMICAL CHARACTERISTICS OF RESERVOIR PROCESSES

2.2.1 CONSTITUENTS

Some of the most important chemical constituents in reservoir waters that affect water quality are needed by aquatic organisms for survival. These include oxygen, carbon, nitrogen, and phosphorus. Other important constituents are silica, manganese, iron, and sulfur.

Dissolved oxygen: Oxygen is a fundamental chemical constituent of water bodies that is essential to the survival of aquatic organisms and is one of the most important indicators of reservoir water quality conditions. The distribution of dissolved oxygen (DO) in reservoirs is a result of dynamic transfer processes from the atmospheric and photosynthetic sources to consumptive uses by the aquatic biota. The resulting distribution of DO in the reservoir water strongly affects the solubility of many inorganic chemical constituents. Often, water quality control or management approaches are formulated to maintain an aerobic, or oxic (i.e., oxygen-containing), environment. Oxygen is produced by aquatic plants (phytoplankton and macrophytes) and is consumed by aquatic plants, other biological organisms, and chemical oxidations. In reservoirs, the DO demand may be divided into two separate but highly interactive fractions: sediment oxygen demand (SOD) and water column oxygen demand.

Sediment oxygen demand: The SOD is typically highest in the upstream area of the reservoir just below the headwaters. This is an area of transition from riverine to lake characteristics. It is relatively shallow but stratifies. The loading and sedimentation of organic matter is high in this transition area and, during stratification, the hypolimnetic DO to satisfy this demand can be depleted. If anoxic conditions develop, they generally do so in this area of the reservoir and progressively move toward the dam during the stratification period. The SOD is relatively independent of DO when DO concentrations in the water column are greater than 3 to 4 mg/l but becomes limited by the rate of oxygen supply to the sediments.

Water column oxygen demand: A characteristic of many reservoirs is a metalimnetic minimum in DO concentrations, or negative heterograde oxygen curve (Figure 2.1). Density interflows not only transport oxygen-demanding material into the metalimnion but can also entrain reduced chemicals from the upstream anoxic area and create additional oxygen demand. Organic matter and organisms from the mixed layer settle at slower rates in the metalimnion because of increased

viscosity due to lower temperatures. Since this labile organic matter remains in the metalimnion for a longer time period, decomposition occurs over a longer time, exerting a higher oxygen demand. Metalimnetic oxygen depletion is an important process in deep reservoirs. A hypolimnetic oxygen demand generally starts at the sediment/water interface unless underflows contribute organic matter that exerts a significant oxygen demand. In addition to metalimnetic DO depletion, hypolimnetic DO depletion also is important in shallow, stratified reservoirs since there is a smaller hypolimnetic volume of oxygen to satisfy oxygen demands than in deeper reservoirs.

Dissolved oxygen distribution: Two basic types of vertical DO distribution may occur in the water column: an orthograde and clinograde DO distribution (Figure 2.1). In the orthograde distribution, DO concentration is a function primarily of temperature since DO consumption is limited. The clinograde DO profile is representative of more productive, nutrient-rich reservoirs where the hypolimnetic DO concentration progressively decreases during stratification and can occur during both summer and winter stratification periods.

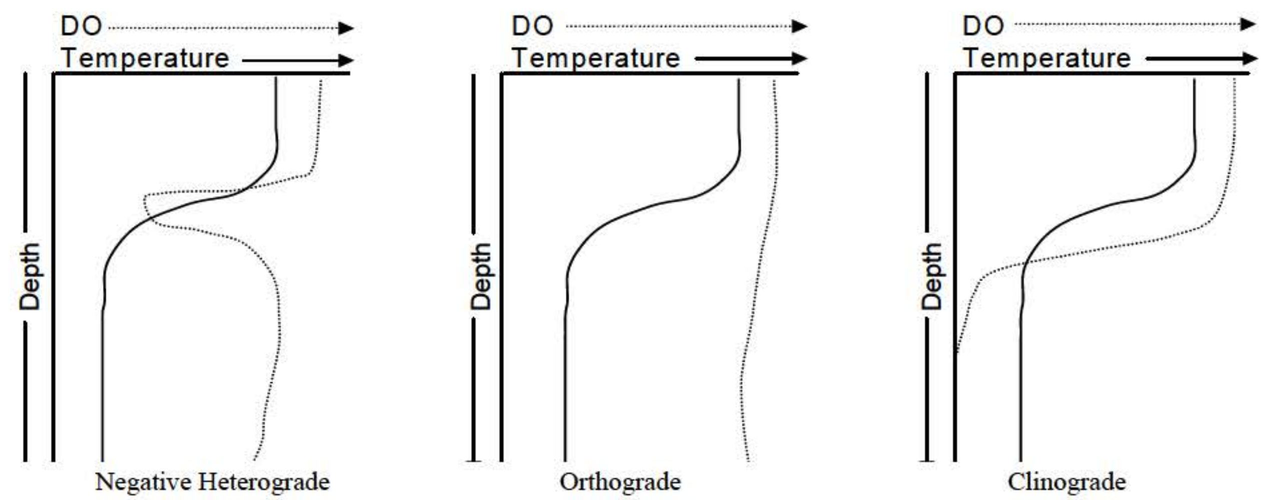

Figure 2.1. Vertical oxygen concentrations possible in thermally stratified lakes.

Inorganic carbon: Inorganic carbon represents the basic building block for the production of organic matter by plants. Inorganic carbon can also regulate the pH and buffering capacity or alkalinity of aquatic systems. Inorganic carbon exists in a dynamic equilibrium in three major forms: carbon dioxide (CO_2), bicarbonate ions (HCO_3), and carbonate ions (CO_3). Carbon dioxide is readily soluble in water and some CO_2 remains in a gaseous form, but the majority of the CO_2 forms carbonic acid that dissociates rapidly into HCO_3 and CO_3 ions. This dissociation results in a weakly alkaline system (i.e., pH $\approx$ 7.1 or 7.2). There is an inverse relationship between pH and CO_2. The pH increases when aquatic plants (phytoplankton or macrophytes) remove CO_2 from the water to form organic matter through photosynthesis during the day. During the night when aquatic plants respire and release CO_2, the pH decreases. The extent of this pH change provides an indication of the buffering capacity of the system. Weakly buffered systems with low alkalinities (i.e., <500 microequivalents per liter) experience larger shifts in pH than well-buffered systems (i.e., >1,000 microequivalents per liter).

Nitrogen: Nitrogen is important in the formulation of plant and animal protein. Nitrogen, similar to carbon, also has a gaseous form. Many species of cyanobacteria can use or fix elemental or gaseous N_2 as a nitrogen source. The most common forms of nitrogen in aquatic systems are ammonia (NH_3-N), nitrite

(NO_2-N), and nitrate (NO_3-N). All three forms are transported in water in a dissolved phase. Ammonia results primarily from the decomposition of organic matter. Nitrite is primarily an intermediate compound in the oxidation or nitrification of ammonia to nitrate, while nitrate is the stable oxidation state of nitrogen and represents the other primary inorganic nitrogen form, besides NH_3, used by aquatic plants.

Phosphorus: Phosphorus is used by both plants and animals to form enzymes and vitamins and to store energy in organic matter. Phosphorus has received considerable attention as the nutrient controlling algal production and densities and associated water quality problems. The reasons for this emphasis are: phosphorus tends to limit plant growth more than the other major nutrients; phosphorus does not have a gaseous phase and ultimately originates from the weathering of rocks; removal of phosphorus from point sources can reduce the growth of aquatic plants; and the technology for removing phosphorus is more advanced and less expensive than nitrogen removal. Phosphorus is generally expressed in terms of the chemical procedures used for measurement: total phosphorus, particulate phosphorus, dissolved or filterable phosphorus, and soluble reactive phosphorus. Phosphorus is a very reactive element; it reacts with many cations such as iron and calcium and is readily sorbed on particulate matter such as clays, carbonates, and inorganic colloids. Since phosphorus exists in a particulate phase, sedimentation represents a continuous loss from the water column to the sediment. Sediment phosphorus, then, may exhibit longitudinal gradients in reservoirs similar to sediment silt/clay gradients. Phosphorus contributions from sediment under anoxic conditions and macrophyte decomposition are considered internal phosphorus sources or loads, and are in a chemical form readily available for plankton uptake and use. Internal phosphorus loading can represent a major portion of the total phosphorus budget.

Silica: Silica is an essential component of diatom algal frustules or cell walls. Silica uptake by diatoms can markedly reduce silica concentrations in the epilimnion and initiate a seasonal succession of diatom species. When silica concentrations decrease below 0.5 mg/l, diatoms generally are no longer competitive with other phytoplankton species.

Other nutrients: Iron, manganese, and sulfur concentrations generally are adequate to satisfy plant nutrient requirements. Oxidized iron (III) and manganese (IV) are quite insoluble in water and occur in low concentrations under aerobic conditions. Under aerobic conditions, sulfur usually is present as sulfate.

2.2.2 ANAEROBIC (ANOXIC) CONDITIONS

When dissolved oxygen concentrations in the hypolimnion are reduced to approximately 2 to 3 mg/l, the oxygen regime at the sediment/water interface is generally considered anoxic, and anaerobic processes begin to occur in the sediment interstitial water. Nitrate reduction to ammonium and/or N_2O or N_2 (denitrification) is considered to be the first phase of the anaerobic process and places the system in a slightly reduced electrochemical state. Ammonium-nitrogen begins to accumulate in the hypolimnetic water. The presence of nitrate prevents the production of additional reduced forms such as manganese (II), iron (II), or sulfide species. Denitrification probably serves as the main mechanism for removing nitrate from the hypolimnion. Following the reduction or denitrification of nitrate, manganese species are reduced from insoluble forms (i.e., Mn (IV)) to soluble manganous forms (i.e., Mn (II)), which diffuse into the overlying water column. Nitrate reduction is an important step in anaerobic processes since the presence of nitrate in the water column will inhibit manganese reduction. As the electrochemical potential of the system becomes further reduced, iron is reduced from the insoluble ferric (III) form to the soluble ferrous (II) form and begins to diffuse into the overlying water column. Phosphorus, in many instances, is also transported in a complexed form with insoluble ferric (III) species; therefore, the reduction and solubilization of iron also result in the release and solubilization of phosphorus into the water column. The sediments may serve as a major phosphorus source during anoxic periods and a phosphorus sink during aerobic periods. During this period of anaerobiosis, microorganisms also are

decomposing organic matter into lower molecular weight acids and alcohols such as acetic, fulvic, humic, and citric acids and methanol. These compounds may also serve as trihalomethane precursors (low-molecular weight organic compounds in water; i.e., methane, formate acetate), which, when subject to chlorination during water treatment, form trihalomethanes, or THMs (carcinogens). As the system becomes further reduced, sulfate is reduced to sulfide, which begins to appear in the water column. Sulfide will readily combine with soluble reduced iron (II), however, to form insoluble ferrous sulfide, which precipitates out of solution. If the sulfate is reduced to sulfide and the electrochemical potential is strongly reducing, methane formation from the reduced organic acids and alcohols may occur. Consequently, water samples from anoxic depths will exhibit these chemical characteristics.

Anaerobic processes are generally initiated in the upstream portion of the hypolimnion where organic loading from the inflow is relatively high and the volume of the hypolimnion is minimal, so oxygen depletion occurs rapidly. Anaerobic conditions are generally initiated at the sediment/water interface and gradually diffuse into the overlying water column and downstream toward the dam. Anoxic conditions may also develop in a deep pocket near the dam due to decomposition of autochthonous organic matter settling to the bottom. This anoxic pocket, in addition to expanding vertically into the water column, may also move upstream and eventually meet the anoxic zone moving downstream.

Anoxic conditions are generally associated with the hypolimnion, but anoxic conditions may occur in the metalimnion. The metalimnion may become anoxic due to microbial respiration and decomposition of plankton settling into the metalimnion, microbial metabolism of organic matter entering as an interflow, or entrainment of anoxic hypolimnetic water from the upper portion of the reservoir.

2.3 BIOLOGICAL CHARACTERISTICS AND PROCESSES

2.3.1 MICROBIOLOGICAL

The microorganisms associated with reservoirs may be categorized as pathogenic or nonpathogenic. Pathogenic microorganisms are of a concern from a human health standpoint and may limit recreational and other uses of reservoirs. Nonpathogenic microorganisms are important in that they often serve as decomposers of organic matter and are a major source of carbon and energy for a reservoir. Microorganisms generally inhabit all zones of the reservoir as well as all layers. Seasonally high concentrations of bacteria will occur during the warmer months, but they can be diluted by high discharges. Anaerobic conditions enhance growth of certain bacteria while aeration facilitates the use of bacterial food sources. Microorganisms, bacteria in particular, are responsible for mobilization of contaminants from sediments.

2.3.2 PHOTOSYNTHESIS

Oxygen is a by-product of aquatic plant photosynthesis, which represents a major source of oxygen for reservoirs during the growing season. Oxygen solubility is less during the period of higher water temperatures, and diffusion may also be less if wind speeds are lower during the summer than the spring or fall. Biological activity and oxygen demand typically are high during thermal stratification, so photosynthesis may represent a major source of oxygen during this period. Oxygen supersaturation in the euphotic zone can occur during periods of high photosynthesis.

2.3.3 PLANKTON

Phytoplankton influence dissolved oxygen and suspended solids concentrations, transparency, taste and odor, aesthetics, and other factors that affect reservoir uses and water quality objectives. Phytoplankton are a primary source of organic matter production and form the base of the autochthonous

food web in many reservoirs since fluctuating water levels may limit macrophyte and periphyton production. Phytoplankton can be generally grouped as diatoms, green algae, cyanobacteria, or cryptomonad algae. Chlorophyll *a* represents a common variable used to estimate phytoplankton biomass.

Seasonal succession of phytoplankton species is a natural occurrence in reservoirs. The spring assemblage is usually dominated by diatoms and cryptomonads. Silica depletion in the photic zone and increased settling as viscosity decreases because of increased temperatures usually result in green algae succeeding the diatoms. Decreases in nitrogen or a decreased competitive advantage for carbon at higher pH may result in cyanobacteria succeeding the green algae during summer and fall. Diatoms generally return in the fall, but cyanobacteria, greens, or diatoms may cause algae blooms following fall turnover when hypolimnetic nutrients are mixed throughout the water column. The general pattern of seasonal succession of phytoplankton is fairly constant from year to year. However, hydrologic variability, such as increased mixing and delay in the onset of stratification during cool, wet spring periods, can maintain diatoms longer in the spring and shift or modify the successional pattern of algae in reservoirs.

Phytoplankton grazers can reduce the abundance of algae and alter their successional patterns. Some phytoplankton species are consumed and assimilated more readily and are preferentially selected by consumers. Single-celled diatom and green algae species are readily consumed by zooplankton, while filamentous cyanobacteria are avoided by zooplankters. Altering the fish population can result in a change in the zooplankton population that can affect the phytoplankton population.

2.3.4 ORGANIC CARBON AND DETRITUS

Total organic carbon (TOC) is composed of dissolved organic carbon (DOC) and particulate organic carbon (POC). Detritus represents that portion of the POC that is nonliving. Nearly all the TOC of natural waters consists of DOC and detritus, or dead POC. The processes of decomposition and consumption of TOC are important in reservoirs and can have a significant affect on water quality.

DOC and POC are decomposed by microbial organisms. This decomposition exerts an oxygen demand that can remove dissolved oxygen from the water column. During stratification, the metalimnion and hypolimnion become relatively isolated from sources of dissolved oxygen, and depletion can occur through organic decomposition. There are two major sources of this organic matter: allochthonous (i.e., produced outside the reservoir and transported in) and autochthonous (i.e., produced within the reservoir). Allochthonous organic carbon in small streams may be relatively refractory since it consists of decaying terrestrial vegetation that has washed or fallen into the stream. Larger rivers, however, may contribute substantial quantities of riverine algae or periphyton that decompose rapidly and can exert a significant oxygen demand. Autochthonous sources include dead plankton settling from the mixed layers and macrophyte fragments and periphyton transported from the littoral zone. These sources are also rapidly decomposed.

POC and DOC absorbed onto sediment particles may serve as a major food source for aquatic organisms. The majority of the phytoplankton production enters the detritus food web with a minority being grazed by primary consumers (USACE, 1987). While autochthonous production is important in reservoirs, typically as much as three times the autochthonous production may be contributed by allochthonous material (USACE, 1987).

2.4 BOTTOM WITHDRAWAL RESERVOIRS

Bottom withdrawal structures are located near the deepest part of a reservoir. Bottom withdrawal removes hypolimnetic water and nutrients and may promote movement of interflows or underflow into the hypolimnion. They release cold water from the deep portion of the reservoir; however, this water may be anoxic during periods of stratification. Bottom outlets can cause density interflows or underflows (e.g., flow laden with sediment or dissolved solids) through the reservoir and generally provide little or no direct control over release water quality.

3 MAINSTEM SYSTEM WATER QUALITY MONITORING

3.1 MAINSTEM SYSTEM RESERVOIRS

3.1.1 LONG-TERM, FIXED-STATION AMBIENT MONITORING

Long-term, fixed-station ambient water quality monitoring has occurred at the six Mainstem System reservoirs (i.e., Fort Peck, Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point) for the past 30 years. Recent ambient monitoring conducted by the District at the Mainstem System reservoirs included monthly (i.e., May through September) water quality monitoring at a near-dam, deepwater site. At Garrison and Fort Peck Reservoirs, additional long-term ambient sites were added, respectively, in 2006 and 2007. At Garrison Reservoir, the added sites included three reservoir deepwater locations (Beulah Bay, RM1412; Deepwater Bay, RM1445; and New Town, RM1481) and one inflow location (Missouri River near Williston, ND, RM1553). At Fort Peck Reservoir, the added sites included two reservoir deepwater locations (Hell Creek Bay, RM1805 and Rock Creek Bay, upper reaches of Dry Creek Arm). Water quality monitoring included field measurements and collection of water samples for analytical analysis. Field measurements included surface water transparency (i.e., Secchi depth) and measuring temperature, dissolved oxygen, pH, conductivity, oxidation-reduction potential (ORP), turbidity, and chlorophyll *a* at 1-meter increments from the reservoir surface to the bottom. Near-surface and near-bottom grab samples were collected and delivered to the laboratory where they were analyzed for alkalinity, nitrate/nitrite, total ammonia, total Kjeldahl nitrogen, total and dissolved phosphorus, ortho-phosphorus, suspended solids, total organic carbon, pesticides, and various metals. A near-surface grab sample was also collected in the epilimnion for analysis of chlorophyll *a*, the cyanobacterial toxin microcystins, and phytoplankton taxa occurrence and relative abundance.

3.1.2 BACTERIA MONITORING AT SWIMMING BEACHES

The District has cooperated with the Nebraska Department of Environmental Quality (NDEQ) to monitor bacteria levels present at swimming beaches at the Gavins Point project over the past 5 years. Five swimming beaches on Gavins Point Reservoir and one on Lake Yankton were monitored. Weekly grab samples were collected from May through September and analyzed for fecal coliform and *E. coli* bacteria and the cyanobacterial toxin microcystins. The bacteria monitoring was conducted to meet a 6-hour holding time for collected samples.

3.1.3 INTENSIVE WATER QUALITY SURVEYS

3.1.3.1 Oahe Reservoir

The District completed a 3-year intensive water quality survey at Oahe Reservoir in 2007. The monitoring objectives of the intensive survey was to collect water quality data to spatially describe water quality conditions present in Oahe Reservoir during the late spring and summer and to collect information to facilitate the application of the CE-QUAL-W2 hydrodynamic and water quality model. As part of the intensive survey, seven reservoir sites and two inflow sites were monitored. The seven reservoir sites were relatively equally spaced in deepwater areas from Oahe Dam to near Mobridge, SD. The inflow sites were located on the Missouri and Cheyenne Rivers and were meant to represent water quality conditions of water flowing into Oahe Reservoir. Monthly samples at the reservoir and inflow sites were collected during June through September.

Water quality monitoring at the reservoir sites included field measurements for depth profiling and water transparency and collection of near-surface and near-bottom water samples for laboratory analysis. Monitoring at the inflow sites included field measurements and collection of a near-surface water sample for laboratory analysis. Reservoir depth profiles in 1-meter increments were recorded for temperature, dissolved oxygen, pH, conductivity, ORP, chlorophyll *a*, and turbidity. Field measurements taken at the inflow sites included temperature, dissolved oxygen, pH, conductivity, and turbidity. Near-surface and near-bottom grab samples were analyzed for alkalinity, nitrate/nitrite, total ammonia, total Kjeldahl nitrogen, total phosphorus, ortho-phosphorus, dissolved total phosphorus, total suspended solids, total dissolved solids, total organic carbon, sulfate, iron (total and dissolved), and manganese (total and dissolved). The near-surface samples were also analyzed for chlorophyll *a*, the cyanobacterial toxin microcystins, and phytoplankton taxa occurrence and relative abundance.

3.1.3.2 Fort Randall Reservoir

The District completed the second year of a planned 3-year intensive water quality survey at Fort Randall Reservoir in 2007. The monitoring objectives of the intensive survey were to collect water quality data to spatially describe water quality conditions present in the reservoir during the summer and to collect information to facilitate the application of the CE-QUAL-W2 hydrodynamic and water quality model. As part of the intensive surveys, seven reservoir sites and one inflow site were monitored. The seven reservoir sites were relatively equally spaced in deepwater areas from Fort Randall Dam to near Chamberlain, SD. The inflow site was located on the White River and was meant to represent water quality conditions of water flowing into Fort Randall Reservoir. Monthly samples at the reservoir and inflow sites were collected during June through September.

Water quality monitoring at the reservoir sites included field measurements for depth profiling and water transparency and collection of near-surface and near-bottom water samples for laboratory analysis. Monitoring at the inflow site included field measurements and collection of a near-surface water sample for laboratory analysis. Reservoir depth profiles in 1-meter increments were recorded for temperature, dissolved oxygen, pH, conductivity, ORP, chlorophyll *a*, and turbidity. Field measurements taken at the inflow sites included temperature, dissolved oxygen, pH, conductivity, and turbidity. Near-surface and near-bottom grab samples were analyzed for alkalinity, nitrate/nitrite, total ammonia, total Kjeldahl nitrogen, total phosphorus, ortho-phosphorus, dissolved total phosphorus, total suspended solids, total dissolved solids, total organic carbon, sulfate, iron (total and dissolved), and manganese (total and dissolved). The near-surface samples were also analyzed for chlorophyll *a*, the cyanobacterial toxin microcystins, and phytoplankton taxa occurrence and relative abundance.

3.2 MAINSTEM SYSTEM POWERPLANTS

As part of the operation of the Mainstem System powerplants, water is drawn from the intake structure of each dam and piped through the powerplant in a "raw water" supply line that is tapped for various uses. The "raw water" supply line is an open-ended, flow-through system (i.e., water is continually discharged). A monitoring station, that measures water quality conditions of water drawn from near the start of the "raw water" supply line, has been irregularly maintained at each of the powerplants over the past several years. Recent water quality monitoring has consisted of year-round, hourly measurements of temperature, dissolved oxygen, and conductivity through the use of a data-logger. Monthly grab samples (year-round) have also been collected and analyzed for alkalinity, nitrate/nitrite, total ammonia, total Kjeldahl nitrogen, total and dissolved phosphorus, ortho-phosphorus, total suspended solids, total dissolved solids, total organic carbon, sulfate, pesticides, and various metals. The rate of dam discharge when measurements and samples were taken was determined from powerplant records. The water quality conditions measured in the "raw water" supply lines of the Mainstem System powerplants are believed to represent the water quality conditions present in the reservoirs near the dam intakes and in the tailwaters (i.e., Missouri River) immediately downstream of the dam.

3.3 MISSOURI RIVER FROM FORT RANDALL DAM TO RULO, NE

Since 2003, the District has cooperated with the State of Nebraska (NDEQ) to monitor ambient water quality conditions along the Missouri River from Fort Randall Dam to Rulo, Nebraska. Fixed-station monitoring has occurred at the following nine sites: Fort Randall Dam tailwaters; near Verdel, NE; Gavins Point Dam tailwaters; near Maskell, NE; near Ponca, NE; at Decatur, NE; at Omaha, NE; at Nebraska City, NE; and at Rulo, NE. Water quality monitoring consisted of collecting near-surface grab samples monthly from October through March and biweekly from April through September. The grab samples were collected from the bank in an area of fast current. The collected grab samples were analyzed for alkalinity, nitrate/nitrite, total ammonia, total Kjeldahl nitrogen, total phosphorus, total suspended solids, total organic carbon, chemical oxygen demand, chloride, pesticides, and various metals. Field measurements taken at the time of sample collection included temperature, pH, dissolved oxygen, conductivity, and turbidity.

3.4 MAINSTEM SYSTEM ANCILLARY LAKES – LAKE YANKTON, LAKE POCASSE, AND LAKE AUDUBON

Lake Yankton, Lake Pocasse, and Lake Audubon are ancillary lakes to the Mainstem System reservoirs respectively at the Gavins Point, Oahe, and Garrison projects. Water quality monitoring at these three lakes has been sporadic in the past. The Omaha District initiated ambient water quality monitoring at the lakes in 2006 as part of a 3-year rotational monitoring cycle. However, low-water conditions prevented boat access and, therefore, prevented water quality monitoring at Lake Pocasse in 2006. The three ancillary lakes are scheduled to be monitored again in 2009. Targeted monitoring at the three lakes includes monthly monitoring (May through September) at a near-dam deepwater location. The monitoring is to include field measurements for depth profiling and water transparency and collection of near-surface and near-bottom water samples for laboratory analysis. Depth profiles in 1-meter increments are to be taken for temperature, dissolved oxygen, pH, conductivity, ORP, turbidity, and chlorophyll *a*. Near-surface and near-bottom grab samples will be analyzed for alkalinity, nitrate/nitrite, total ammonia, Kjeldahl nitrogen, total phosphorus, orthophosphorus, total suspended solids, total organic carbon, chlorophyll *a*, microcystins, pesticides, and various metals.

4 WATER QUALITY ASSESSMENT METHODS

4.1 EXISTING WATER QUALITY (2003 THROUGH 2007)

For the purposes of this report, existing water quality is defined as water quality conditions that occurred during the past 5 years (i.e., 2003 through 2007). Water quality monitoring conducted during that period was used to describe existing water quality conditions.

4.1.1 STATISTICAL SUMMARY AND COMPARISON TO APPLICABLE WATER QUALITY STANDARDS CRITERIA

Statistical analyses were performed on the water quality monitoring data collected at the Mainstem System reservoirs (including inflow and outflow sites), powerplants, on the Missouri River, and at the Mainstem System ancillary lakes. Descriptive statistics were calculated to describe central tendencies and the range of observations in existing water quality. Monitoring results were compared to applicable water quality standards criteria established by the appropriate States pursuant to the Federal CWA. Tables were constructed that list the parameters measured; number of observations; and the mean, median, minimum, and maximum of the data collected. The constructed tables also list the water quality standards criteria applicable to the individual parameters and the frequency that these criteria were not met.

4.1.2 SPATIAL VARIATION IN WATER QUALITY CONDITIONS

4.1.2.1 <u>Longitudinal Variation</u>

4.1.2.1.1 Reservoir Contour Plots

Longitudinal contour plots were constructed when adequate depth-profile measurements were collected along the length of a reservoir. Adequate information was collected in 2007 to construct longitudinal contour plots at four Mainstem System reservoirs: Fort Peck, Garrison, Oahe, and Fort Randall. At these reservoirs longitudinal contour plots were constructed for water temperature, dissolved oxygen, and turbidity. The longitudinal contour plots were constructed using the "Hydrologic Information Plotting Program" included in the "Data Management and Analysis System for Lakes, Estuaries, and Rivers" (DASLER-X) software developed by HydroGeoLogic Inc. (HydroGeologic Inc., 2005).

4.1.2.1.2 Reservoir Box Plots

Longitudinal box plots were constructed when adequate measurements were collected along the length of a reservoir and significant variation was observed in the measurements. Adequate information was collected to construct longitudinal box plots of existing water quality conditions at four Mainstem System reservoirs: Fort Peck, Garrison, Oahe, and Fort Randall.

4.1.2.1.3 Lower Missouri River Box Plots

Longitudinal box plots were constructed for the lower Missouri River. The box plots were constructed from the water quality monitoring conducted in cooperation with the NDEQ during the period

2003 through 2007. The box plots orient and display the distribution of selected water quality parameters measured at the seven monitored sites from Gavins Point Dam to Rulo, NE.

4.1.2.2 Vertical Variation in Lake Water Quality

Depending on their depth and bathymetry, lakes can experience thermally-induced density stratification in the summer. This can lead to significant vertical water quality variation if anoxic or near-anoxic conditions develop in the hypolimnion.

4.1.2.2.1 Summer Depth-Profile Plots

Measured water temperature and dissolved oxygen depth profiles were plotted at the Mainstem System reservoirs and Mainstem System ancillary lakes. The plotted depth profiles were measured at the near-dam, deepwater ambient monitoring location. Depth profiles measured in the months of July, August, and September over the past 5 years were plotted. The plots were reviewed to assess the occurrence of thermal stratification and hypolimnetic dissolved oxygen degradation.

4.1.2.2.2 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

The variation of selected parameters with depth was evaluated by comparing near-surface and near-bottom collected samples. The compared samples were collected at the near-dam, deepwater monitoring location over the past 5 years. The parameters compared included water temperature, dissolved oxygen, and various nutrients.

4.1.3 TEMPORAL VARIATION IN WATER QUALITY CONDITIONS

4.1.3.1 Time Series Plots of Water Temperatures Measured in the Missouri River Upstream and Downstream of the Mainstem System Reservoirs

Annual seasonal time series plots of water temperatures measured in the Missouri River immediately upstream and downstream of the Mainstem System reservoirs were constructed to display temporal variation.

4.1.3.2 Time-Series Plots of Flow, Water Temperature, and Dissolved Oxygen of Water Discharged through the Mainstem System Dams

Time series plots were prepared for water quality conditions monitored at the Missouri River Mainstem System powerplants during 2005, 2006, and 2007. Hourly water temperature, dissolved oxygen, and dam discharge were plotted semi-annually for the 3 years. Water temperature and dissolved oxygen plots represent monitoring of water drawn from the “raw water” supply line in each powerplant.

4.1.4 TROPHIC STATUS

A Trophic State Index (TSI) was calculated, as described by Carlson (1977). TSI values were determined from Secchi depth transparency, total phosphorus, and chlorophyll *a* measurements. Values for these three parameters were converted to an index number ranging from 0 to 100 according to the following equations:

$$\text{TSI(Secchi Depth)} = \text{TSI(SD)} = 10[6 - (\ln \text{SD}/\ln 2)]$$
$$\text{TSI(Chlorophyll } a) = \text{TSI(Chl)} = 10[6 - ((2.04-0.68 \ln \text{Chl})/\ln 2)]$$
$$\text{TSI(Total Phosphorus)} = \text{TSI(TP)} = 10[6 - (\ln (48/\text{TP})/\ln 2)]$$

Accurate TSI values from total phosphorus depend on the assumptions that phosphorus is the major limiting factor for algal growth and that the concentrations of all forms of phosphorus present are a function of algal biomass. Accurate TSI values from Secchi depth transparency depend on the assumption that water clarity is primarily limited by phytoplankton biomass. Carlson indicates that the chlorophyll TSI value may be a better indicator of a lake's trophic conditions during mid-summer when algal productivity is at its maximum, while the total phosphorus TSI value may be a better indicator in the spring and fall when algal biomass is below its potential maximum. Calculation of TSI values from data collected from a lake's epilimnion during summer stratification provide the best agreement between all of the index parameters and facilitate comparisons between lakes. Carlson states that care must be taken if a TSI average score is calculated from the three individual parameter TSI values. If significant differences exist between parameter TSI values, the calculated average value may not be indicative of the trophic condition estimated by the individual parameter values. With this consideration, a TSI average value [TSI(Avg)] calculated as the average of the three individually determined TSI values [i.e., TSI(SD), TSI(Chl), and TSI(TP)] is used by the District as an overall indicator of a reservoir's trophic state. The District uses the criteria defined in Table 4.1 for determining lake trophic status from TSI values.

Table 4.1. Lake trophic status based on calculated TSI values.

TSI	Trophic Condition
0-35	Oligotrophic
36-50	Mesotrophic
51-55	Moderately Eutrophic
56-65	Eutrophic
66-100	Hypereutrophic

4.1.5 MAINSTEM SYSTEM RESERVOIR PHYTOPLANKTON COMMUNITY

Assessment of the phytoplankton community was based on grab samples that were analyzed by a contract laboratory. Laboratory analyses consisted of identification of phytoplankton taxa to the lowest practical level and quantification of taxa biovolume. These results were used to determine the relative abundance of phytoplankton taxa at the division level based on the measured biovolumes.

4.1.6 ATTAINMENT OF WATER QUALITY STANDARDS

The attainment of water quality standards was assessed by determining the support of designated water quality beneficial uses. Where applicable water quality standards criteria existed, beneficial support was determined by the number of times the criteria were exceeded during the 5-year period of 2003 through 2007 based on water quality monitoring conducted by the District. The following water quality standards attainment ratings were defined: 1) Full Support (less than 10% of the observations exceed criteria), 2) Not Supported (greater than 20% of the observations exceed criteria), and 3) Threatened or Partial Support (10-20% of observations exceed criteria). It is noted that the "official" determination of whether water quality standards are being attained, pursuant to the Federal CWA, is identified by the States pursuant to their Section 305(b) and Section 303(d) assessments (See Table 1.3).

4.2 WATER QUALITY TRENDS

Surface water quality trends were assessed by evaluating water clarity (i.e. Secchi depth), total phosphorus, chlorophyll *a*, and calculated TSI(Avg) values from monitoring results obtained at long-term, fixed-station ambient monitoring sites for the period 1980 to 2007.

5 MAINSTEM SYSTEM RESERVOIRS

5.1 BACKGROUND INFORMATION

The Mainstem System is comprised of six dams and reservoirs constructed by the Corps on the Missouri River and, where present, the free-flowing Missouri River downstream of the dams. The six reservoirs impounded by the dams contain about 73.3 million acre-feet (MAF) of storage capacity and, at normal pool, an aggregate water surface area of about 1 million acres. The six dams and reservoirs in an upstream to downstream order are: Fort Peck Dam and Reservoir (MT), Garrison Dam and Reservoir (ND), Oahe Dam (SD) and Oahe Reservoir (ND and SD), Big Bend Dam and Reservoir (SD), Fort Randall Dam and Reservoir (SD), and Gavins Point Dam and Reservoir (SD and NE). The water in storage at the all Mainstem System reservoirs at the end of 2007 (i.e., December 31, 2007) was 36.84 MAF, which is about 50 percent of the total Mainstem System storage volume. Drought conditions in the upper Missouri River Basin since 2000 have reduced the water stored in the upper three Mainstem System reservoirs to record low levels.

5.1.1 REGULATION OF THE MAINSTEM SYSTEM

The Mainstem System is a hydraulically and electrically integrated system that is regulated to obtain the optimum fulfillment of the multipurpose benefits for which the dams and reservoirs were authorized and constructed. The Congressionally authorized purposes of the Mainstem System are flood control, navigation, hydropower, water supply, water quality, irrigation, recreation, and fish and wildlife (including threatened and endangered species). The Mainstem System is operated under the guidelines described in the Missouri River Mainstem System Master Water Control Manual, (Master Manual) (USACE-RCC, 2006). The Master Manual details regulation for all authorized purposes as well as emergency regulation procedures in accordance with the authorized purposes.

Mainstem System regulation is, in many ways, a repetitive annual cycle that begins in late winter with the onset of snowmelt. The annual melting of mountain and plains snow packs along with spring and summer rainfall produces the annual runoff into the Mainstem System. In a typical year, mountain snow pack, plains snow pack, and rainfall events respectively contribute 50, 25, and 25% of the annual runoff to the Mainstem System. After reaching a peak, usually during July, the amount of water stored in the Mainstem System declines until late in the winter when the cycle begins anew. A similar pattern may be found in rates of releases from the Mainstem System, with the higher levels of releases from mid-March to late November, followed by low rates of winter discharge from late November until mid-March, after which the cycle repeats.

To maximize the service to all of the authorized purposes, given the physical and authorization limitations of the Mainstem System, the total storage available in the Mainstem System is divided into four regulation zones that are applied to the individual reservoirs. These four regulation zones are: 1) Exclusive Flood Control Zone, 2) Annual Flood Control and Multiple Use Zone, 3) Carryover Multiple Use Zone, and 4) Permanent Pool Zone.

5.1.1.1 Exclusive Flood Control Zone

Flood control is the only authorized purpose that requires empty space in the reservoirs to achieve the objective. A top zone in each Mainstem System reservoir is reserved for use to meet the flood control requirements. This storage space is used only for detention of extreme or unpredictable flood flows and is evacuated as rapidly as downstream conditions permit, while still serving the overall flood control

objective of protecting life and property. The Exclusive Flood Control Zone encompasses 4.7 MAF and represents the upper 6 percent of the total Mainstem System storage volume. This zone, from 73.3 MAF down to 68.7 MAF, is normally empty. The four largest reservoirs, Fort Peck, Garrison, Oahe, and Fort Randall, contain 97 percent of the total storage reserved for the Exclusive Flood Control Zone.

5.1.1.2 Annual Flood Control and Multiple Use Zone

An upper "normal operating zone" is reserved annually for the capture and retention of runoff (normal and flood) and for annual multiple-purpose regulation of this impounded water. The Mainstem System storage capacity in this zone is 11.7 MAF and represents 16 percent of the total Mainstem System storage. This storage zone, which extends from 68.7 MAF down to 57.0 MAF, will normally be evacuated to the base of this zone by March 1 to provide adequate storage capacity for capturing runoff during the next flood season. On an annual basis, water will be impounded in this zone, as required to achieve the Mainstem System flood control purpose and also be stored in the interest of general water conservation to serve all the other authorized purposes. The evacuation of water from the Annual Flood Control and Multiple Use Zone is scheduled to maximize service to the authorized purposes that depend on water from the Mainstem System. Scheduling releases from this zone is limited by the flood control objective in that the evacuation must be completed by the beginning of the next flood season. This is normally accomplished as long as the evacuation is possible without contributing to serious downstream flooding. Evacuation is, therefore, accomplished mainly during the summer and fall because Missouri River ice formation and the potential for flooding from higher release rates limit release rates during the December through March period.

5.1.1.3 Carryover Multiple Use Zone

The Carryover Multiple Use Zone is the largest storage zone extending from 57.0 MAF down to 18.0 MAF, and represents 53 percent of the total Mainstem System storage volume. Serving the authorized purposes during an extended drought is an important regulation objective of the Mainstem System. The Carryover Multiple Use Zone provides a storage reserve to support authorized purposes during drought conditions. Providing this storage is the primary reason the upper three reservoirs of the Mainstem System are so large compared to other Federal water resource projects. The Carryover Multiple Use Zone is often referred to as the "bank account" for water in the Mainstem System because of its role in supporting authorized purposes during critical dry periods when the storage in the Annual Flood Control and Multiple Use Zone is exhausted. Only the reservoirs at Fort Peck, Garrison, Oahe, and Fort Randall have this storage as a designated storage zone. The three larger reservoirs (Fort Peck, Garrison, and Oahe) provide water to the Mainstem System during drought periods to provide for authorized purposes. The storage space assigned to this zone in Fort Randall Reservoir serves a different purpose. It is normally evacuated each year during the fall season to provide recapture space for upstream winter power releases. The recapture results in complete refill of Fort Randall Reservoir during the winter months. During drought periods, the three smaller projects (Fort Randall, Big Bend, and Gavins Point) reservoir levels are maintained at the same elevation they would be at if runoff conditions were normal.

5.1.1.4 Permanent Pool Zone

The Permanent Pool Zone is the bottom zone that is intended to be permanently filled with water. The zone provides for future sediment storage capacity and maintenance of minimum pool levels for power heads, irrigation diversions, water supply, recreation, water quality, and fish and wildlife. A drawdown into this zone will generally not be scheduled except in unusual conditions. The Mainstem System storage capacity in this storage zone is 18.0 MAF and represents 25 percent of the total storage volume. The Permanent Pool Zone extends from 18.0 MAF down to 0 MAF.

5.1.2 WATER CONTROL PLAN FOR THE MAINSTEM SYSTEM

Variations in runoff into the Mainstem System necessitates varied regulation plans to accommodate the multipurpose regulation objectives. The two primary high-risk flood seasons are the plains snowmelt and rainfall season extending from late February through April, and the mountain snowmelt and rainfall period extending from May through July. Also, the winter ice-jam flood period, which extends from mid-December through February, can be a high-risk flood period. The highest average power generation period extends from mid-April to mid-October, with high peaking loads during the winter heating season (mid-December to mid-February) and the summer air conditioning season (mid-June to mid-August). The power needs during the winter are supplied primarily with Fort Peck and Garrison Dam releases and the peaking capacity of Oahe and Big Bend Dams. During the spring and summer period, releases are normally geared to navigation and flood control requirements, and primary power loads are supplied using the four lower dams. During the fall when power needs diminish, Fort Randall is normally drawn down to permit generation during the winter period when Oahe and Big Bend peaking-power releases refill the reservoir. The normal 8-month navigation season extends from April 1 through November 30, during which time Mainstem System releases are increased to meet downstream target flows in combination with downstream tributary inflows. Winter releases after the close of the navigation season are much lower and vary depending on the need to conserve or evacuate storage volumes, downstream ice conditions permitting. Releases and pool fluctuations for fish spawning management generally occur from April 1 through June. Two threatened and endangered bird species, piping plover (*Charadrius melodus*) and least tern (*Sterna antillarum*), nest on "sandbar" areas from early May through mid-August. Other factors may vary widely from year to year, such as the amount of water-in-storage and the magnitude and distribution of inflow received during the coming year. All these factors will affect the timing and magnitude of Mainstem System releases. The gain or loss in the water stored at each reservoir must also be considered in scheduling the amount of water transferred between reservoirs to achieve the desired storage levels and to generate power. These items are continually reviewed as they occur and are appraised with respect to the expected range of regulation.

5.1.3 OCCURRENCE OF "TWO-STORY" FISHERIES

Fort Peck, Garrison, and Oahe Reservoirs maintain "two-story" fisheries that are comprised of warmwater and coldwater species. The ability of the reservoirs to maintain "two-story" fisheries is due to their thermal stratification in the summer into a colder bottom region and a warmer surface region. Warmwater species present in the reservoirs that are recreationally important include walleye (*Sander vitreus*), sauger (*Sander canadensis*), northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieu*), catfish (*Ictalurus spp.*), and yellow perch (*Perca flavescens*). Coldwater species of recreational importance are the Chinook salmon (*Oncorhynchus tshawytscha*) and lake trout (*Salvelinus namaycush*). Chinook salmon are maintained in all three reservoirs through regular stocking, and lake trout are present in Fort Peck Reservoir. Other coldwater species present are rainbow smelt (*Osmerus mordax*) in Oahe and Garrison Reservoirs and lake cisco (*Coregonus artedi*) in Fort Peck Reservoir. Both these species are important forage fish that are utilized extensively by all recreational species in the respective reservoirs. Maintaining healthy populations of these coldwater forage fish are important to maintaining the recreational fisheries in the three reservoirs.

The occurrence of coldwater habitat in Fort Peck, Garrison, and Oahe Reservoirs is directly dependent on each reservoir's annual thermal regime. Early in the winter ice-cover period, the entire reservoir volume will be supportive of coldwater habitat. As the winter ice-cover period continues, lower dissolved oxygen concentrations will likely occur near the bottom as organic matter decomposes and reservoir mixing is prevented by ice cover. As dissolved oxygen concentrations in the near-bottom water fall below 5 mg/l, coldwater habitat will not be supported. During the spring isothermal period, water temperatures and dissolved oxygen levels in the entire reservoir volume will be supportive of coldwater

habitat. During the early-summer warming period, the epilimnion will become non-supportive of coldwater habitat. During mid-summer when the reservoirs are experiencing maximum thermal stratification, water temperatures will only be supportive of coldwater habitat in the hypolimnion. Theoretically, coldwater habitat should remain stable during this period unless degradation of dissolved oxygen concentrations near the reservoir bottom becomes non-supportive of coldwater habitat. The most crucial period for the support of coldwater habitat in the three reservoirs is when they begin to cool in late summer. As the thermocline moves deeper, the volume of the coldwater hypolimnion will continue to decrease while the expanding epilimnion may not yet be cold enough to be supportive of coldwater habitat. At the same time, hypolimnetic dissolved oxygen concentrations are approaching their maximum degradation and low dissolved oxygen levels are moving upward from the reservoir bottom and pinching off coldwater habitat from below. This situation will continue to worsen until the epilimnion cools enough to be supportive of coldwater habitat. When fall turnover occurs, dissolved oxygen concentrations at all depths will be near saturation and supportive of coldwater habitat. However, depending on the conditions of the reservoir, the isothermal temperature at the beginning of fall turnover may not be supportive of all coldwater habitats. This situation will continue to occur until the isothermal temperature cools to a suitable temperature, at which time the entire reservoir volume will be supportive of coldwater habitat.

5.2 FORT PECK

5.2.1 BACKGROUND INFORMATION

5.2.1.1 Project Overview

Fort Peck Dam is located on the Missouri River at river mile (RM) 1771.5 in northeastern Montana, 17 miles southeast of Glasgow, MT. The closing of Fort Peck Dam in 1937 resulted in the formation of Fort Peck Reservoir (Fort Peck Lake). When full, the reservoir is 134 miles long, covers 246,000 acres, and has 1,520 miles of shoreline. Table 5.1 summarizes how the surface area, volume, mean depth, and retention time of Fort Peck Reservoir vary with pool elevations. Due to ongoing drought conditions, the reservoir at the end of December 2007 was at pool elevation 2199.5 ft-msl. This is 34.5 feet below the top of the Carryover Multiple Use Zone (2234.0 ft-msl). Major inflows to the reservoir come from the Missouri River, Musselshell River, and Big Dry Creek. Water discharged through Fort Peck Dam for power production is withdrawn from Fort Peck Reservoir at elevation 2095 ft-msl – approximately 65 feet above the reservoir bottom.

Fort Peck was authorized for the purposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. Over the period 1967 through 2007, the five generating units at Fort Dam have produced an annual average 1.075 million mega-watt hours (MWh) of electricity, which has a current revenue value of approximately $17 million. The ongoing drought in the western United States has curtailed releases and power production at the Mainstem System projects, including Fort Peck. Power production at the Fort Peck Dam generating units averaged an annual 0.683 MWh over the 5-year period 2003 through 2007. Habitat for one endangered species, pallid sturgeon (*Scaphirhynchus albus*), occurs within the project area. The reservoir is used as a water supply by the town of Fort Peck, MT and by numerous individual cabins in the area. Fort Peck Reservoir is an important recreational resource and a major visitor destination in Montana.

5.2.1.2 Water Quality Standards Classifications and Section 303(d) Listings

5.2.1.2.1 Fort Peck Reservoir

The State of Montana has assigned Fort Peck Reservoir a B-3 classification in the State's water quality standards. As such, the reservoir is to be maintained suitable for drinking, culinary, and food

Table 5.1. Surface area, volume, mean depth, and retention time of Fort Peck Reservoir at different pool elevations.

Pool Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
2250	245,898	18,687,731	76.0	2.76
2245	238,094	17,474,394	73.4	2.58
2240	226,691	16,309,409	71.9	2.41
2235	214,031	15,208,569	71.1	2.25
2230	200,563	14,169,579	70.6	2.09
2225	187,984	13,202,148	70.2	1.95
2220	179,404	12,236,952	68.2	1.81
2215	172,112	11,407,020	66.3	1.68
2210	164,592	10,565,907	64.2	1.56
2205	157,232	9,761,001	62.1	1.44
2200	149,653	8,993,723	60.1	1.33
2195	142,016	8,264,516	58.2	1.22
2190	134,099	7,573,749	56.5	1.12
2185	126,382	6,923,345	54.8	1.02
2180	119,809	6,309,129	52.7	0.93
2175	113,166	5,725,330	50.6	0.85
2170	104,794	5,178,658	49.4	0.76
2165	96,624	4,677,236	48.4	0.69
2160	90,348	4,211,053	46.6	0.62

Average Annual Inflow (1967 through 2007) = 7.27 Million Acre-Feet
Average Annual Outflow: (1967 through 2007) = 6.77 Million Acre-Feet
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 2250-2246 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 2246-2234 ft-msl), Carryover Multiple Use Zone (elev. 2234-2160 ft-msl), and Permanent Pool Zone (elev. 2160-2030 ft-msl). All elevations are in the NGVD 29 datum.

processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply. Pursuant to Section 303(d) of the Federal CWA, Montana has placed Fort Peck Reservoir on the State's list of impaired waters citing impairment to the uses of drinking water supply and primary contact recreation due to the pollutants of lead, mercury, and native aquatic plants. The identified sources of these pollutants are agriculture, abandoned mining, atmospheric deposition, and historic bottom deposits. The State of Montana has also issued a fish consumption advisory for the reservoir due to mercury concerns.

5.2.1.2.2 Missouri River Downstream of Fort Peck Dam

The Missouri River downstream of Fort Peck Dam has been designated a B-2 classification from the dam to the confluence of the Milk River, and a B-3 classification from the Milk River confluence to the Montana/North Dakota state line (Montana water quality standards). Both B-2 and B-3 waters are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; waterfowl and furbearers; and agricultural and industrial water supply. In addition, B-2 waters are to maintain growth and marginal propagation of salmonid fishes and associated aquatic life, and B-3 waters are to maintain growth and propagation of non-salmonid fishes and associated aquatic life. The river is used as a water supply by several towns along the reach. Pursuant to Section 303(d) of the Federal CWA, Montana has placed the Missouri River downstream of Fort Peck

Dam on the State's list of impaired waters citing impairment to the uses of aquatic life support, coldwater fishery, and warmwater fishery due to the stressors of flow alteration, riparian alteration, and water temperature. The identified probable sources of these stressors are dam/impoundment, impacts from hydrostructure, flow regulation/modification, and loss of riparian habitat. No fish consumption advisory has been issued for the Missouri River downstream of Fort Peck Dam by the State of Montana.

5.2.1.3 Water Quality for the Enhancement of Pallid Sturgeon Populations in the Missouri River Downstream of Fort Peck Dam

One of the few remaining populations of pallid sturgeon occurs in the Missouri River between Fort Peck Dam and the headwaters of Garrison Reservoir. Individuals in this population also inhabit the lower Yellowstone River. As such, this reach of the Missouri River has been identified as a priority recovery area for the pallid sturgeon (USFWS, 1993). It is hypothesized that the building and operation of Fort Peck Dam and Reservoir have adversely impacted the pallid sturgeon in this reach of the Missouri River by regulating flows, lowering water temperatures, reducing sediment and nutrient transport, and increasing water clarity.

Historically, the lower Missouri River in Montana was a turbid, warmwater environment with seasonally fluctuating flows. The sediment and turbidity of the water through these cycles contributed significantly to the evolution of the pallid sturgeon. The fish adapted to highly turbid and low visibility environments by physiologically evolving to enhance their ability to capture prey and avoid capture as juveniles and larvae in this low visibility environment. It is also believed that the pallid sturgeon adapted by developing spawning cues based on historical conditions in the river. The fish requires a spawning cue of suitable magnitude, duration, and timing to complete this life cycle element. It is believed that increasing flow and water temperature in the late spring is a primary factor for pallid sturgeon to initiate spawning.

Water temperature is believed to be a controlling factor on the pallid sturgeon in this reach of the Missouri River in regards to spawning cues and larval survival during the summer. Because Fort Peck Dam has a deepwater withdrawal from the reservoir, water temperature in the Missouri River downstream of the dam are appreciably colder than "pre-dam" conditions. A water temperature of around 18°C (64.4°F) is believed necessary to initiate a spawning response in pallid sturgeon. Additionally, a dramatic decline in water temperatures after spawning can affect larval pallid sturgeon development and likely adversely affect the production and availability of suitable forage (i.e., plankton and other invertebrate species) for the juvenile pallid sturgeon throughout the summer. Low water temperatures may induce mortality in young pallid sturgeon. With this in mind, a late-spring/early-summer water temperature of 18°C in the Missouri River at Frazer Rapids (approximately 25 miles downstream of Fort Peck Dam) has been identified as critical for pallid sturgeon spawning and recruitment in this reach of the river.

Fort Peck Reservoir is trapping sediment that historically moved down the Missouri River through the reach downstream of the dam. It is also believed that the current colder water temperatures in the river are likely suppressing production of plankton and other invertebrate organisms that contribute to turbidity of the water. The resulting clearer water is believed to adversely affect young pallid sturgeon by making them more vulnerable to sight-feeding predators and increasing competition for food by sight-adapted predators. In addition, adult fish may be adversely affected by the increased ability of prey to avoid capture in clearer water.

5.2.1.4 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Fort Peck Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the inflow to and outflow

from the reservoir. A 3-year intensive water quality survey was completed at the Fort Peck Project in 2006, and the findings of the intensive survey are available in the separate report, "Water Quality Conditions Monitored at the Corps' Fort Peck Project in Montana during the 3-Year period 2004 through 2006" (USACE, 2007). Figure 5.1 shows the location of sites at the Fort Peck Project that have been monitored for water quality during the past 5 years (i.e., 2003 through 2007). The near-dam location (i.e., site FTPLK1772A) has been continuously monitored since 1980.

5.2.2 WATER QUALITY IN FORT PECK RESERVOIR

5.2.2.1 <u>Existing Water Quality Conditions (2003 through 2007)</u>

5.2.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Water quality conditions that were monitored in Fort Peck Reservoir at sites FTPLK1772A, FTPLK1778DW, FTPLK1789DW, FTPLK1805DW, FTPLKBDCA01, and FTPLKBDCA02 from May through September during the 5-year period 2003 through 2007 are summarized in Plates 1 through 6. A review of these results found no significant water quality concerns. On a few occasions measured dissolved oxygen concentrations were below the water quality standards criterion of 5 mg/l for the protection of Class B-3 warmwater aquatic life. The measured low dissolved oxygen concentrations occurred in the hypolimnion near the reservoir bottom during the later part of the summer thermal stratification period. The lowest dissolved oxygen concentration measured was 2.2 mg/l and occurred at site FTPLK1789DW on August 30, 2006.

5.2.2.1.2 Summer Thermal Stratification

5.2.2.1.2.1 2007 Monthly Longitudinal Temperature Contour Plots

Summer thermal stratification of Fort Peck Reservoir during 2007 is described by the monthly longitudinal temperature contour plots based on depth-profile temperature measurements taken in June, July, August, and September (Plates 7-10). The contour plots were constructed along two longitudinal axes; the Missouri River mainstem arm and the Big Dry Creek Arm. As seen in Plates 7 through 10, temperatures in Fort Peck Reservoir vary longitudinally from the dam to the reservoirs upper reaches and vertically from the reservoir surface to the bottom. The near-surface water in the upper reaches of the reservoir warms up sooner in the spring than the near-surface water near the dam (Plates 7). By mid-summer a strong thermocline becomes established in the lower reaches of the reservoir, and the near-surface waters of the entire reservoir above the thermocline are a fairly uniform temperature (Plates 8 and 9). As the near-surface waters of the reservoir cool in the late summer, the thermocline is pushed deeper, and these wind-mixed upper waters are fairly uniform in temperature (Plate 10). The vertical variation in temperature is most prevalent in the deeper area of the reservoir towards the dam, where a strong thermocline becomes established during the summer. The shallower upper reaches of Fort Peck Reservoir do not exhibit much vertical variation of temperature during mid- to late summer, as wind action allows for complete mixing of the water column.

5.2.2.1.2.2 Near-Dam Temperature Depth-Profile Plots

Existing summer thermal stratification of Fort Peck Reservoir at the deep water area near the dam is described by the depth-profile temperature plots measured over the past 5 years. Depth-profile temperature plots measured during the summer were compiled (Plate 11). The plotted depth-profile measurements indicate that a significant temperature-depth gradient occurs in Fort Peck Reservoir in the near-dam lacustrine area during the summer, and a thermocline becomes established at a depth of about 20 meters (Plate 11).

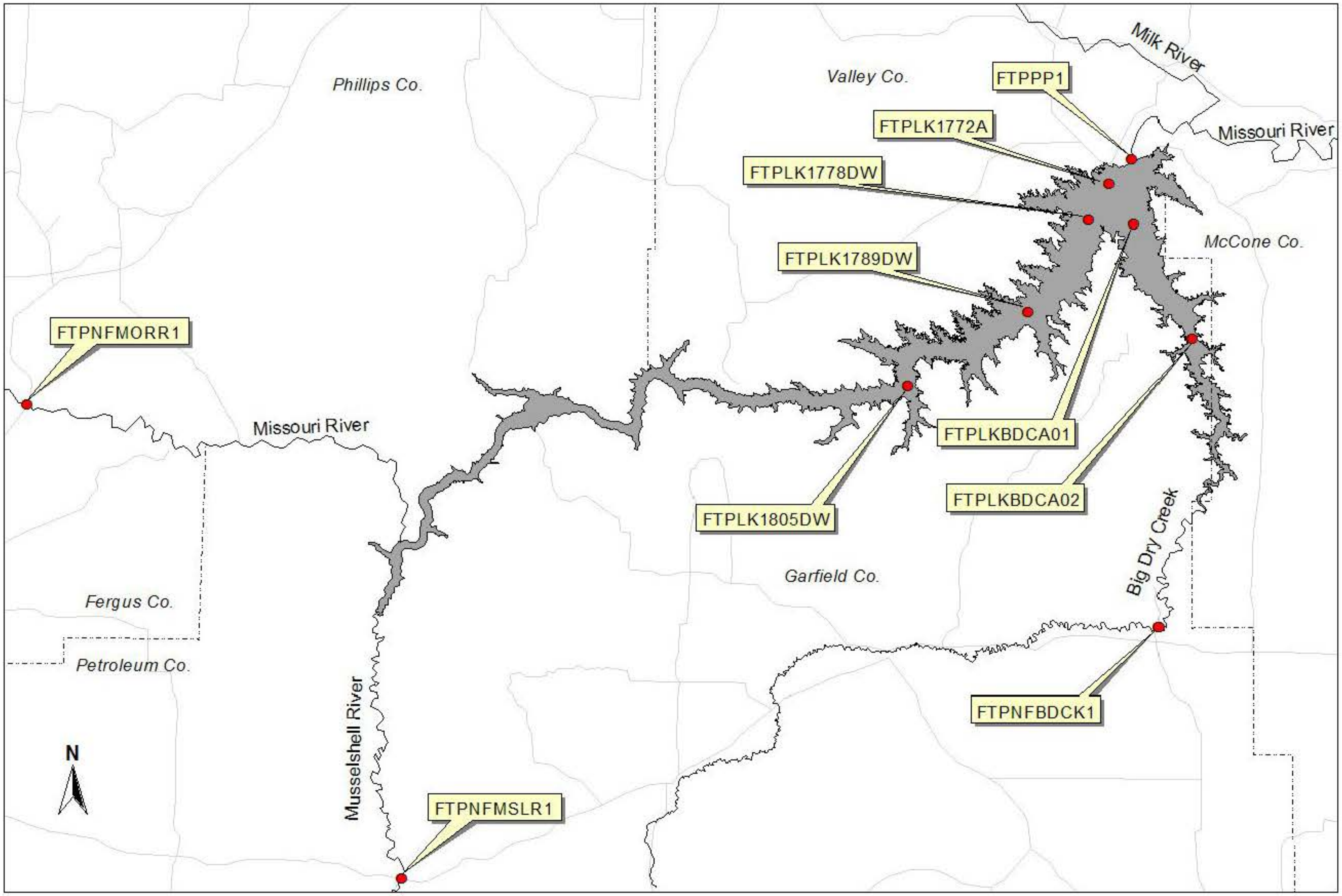

Figure 5.1. Location of sites where water quality monitoring was conducted by the District at the Fort Peck Project during the period 2003 through 2007.

5.2.2.1.3 Summer Dissolved Oxygen Conditions

5.2.2.1.3.1 2006 Monthly Longitudinal Dissolved Oxygen Contour Plots

Summer dissolved oxygen conditions in Fort Peck Reservoir during 2007 are described by the monthly longitudinal dissolved oxygen contour plots based on depth-profile temperature measurements taken in June, July, August, and September (Plates 12-15). The contour plots were constructed along two longitudinal axes; the Missouri River mainstem arm and the Big Dry Creek Arm. As seen in Plates 12 through 15, dissolved oxygen conditions in Fort Peck Reservoir vary longitudinally from the dam to the reservoirs upper reaches and vertically from the reservoir surface to the bottom. Dissolved oxygen levels below 5 mg/l first appeared near the reservoir bottom in the middle reaches of the Missouri River Arm in August (Plates 14). The lowest dissolved oxygen concentrations remained in this area of the reservoir through fall turnover (Plates 15). Near-bottom dissolved oxygen concentrations near the dam remained above 5 mg/l. The earlier occurrence of low dissolved oxygen concentrations in the near-bottom water of the middle reaches of Fort Peck Reservoir is attributed to the increased allochthonous organic loading in the transition zone of the reservoir and the lesser hypolimnetic volume available for assimilation of the oxygen demand. As this material decomposes, a "pool" of water with low dissolved oxygen levels accumulates near the bottom in this area of the reservoir. Decomposition of autochthonous organic matter also occurs in the lacustrine zone and results in dissolved oxygen degradation as the summer progresses, although at a slower rate than what occurs in the transition zone. The recovery of near-bottom dissolved oxygen concentrations to saturation levels takes longer in the lacustrine zone nearer the dam because of the time needed for thermal stratification to breakdown and mixing within the water column to occur in the deeper water.

5.2.2.1.3.2 Near-Dam Dissolved Oxygen Depth-Profile Plots

Existing summer dissolved oxygen conditions in Fort Peck Reservoir at the deep water area near the dam is described by the depth-profile dissolved oxygen plots measured over the past 5 years. Depth-profile dissolved oxygen plots measured during the month of June, July, August, and September were compiled (Plate 16). Dissolved oxygen levels did not exhibit a large gradient with depth and tended toward an orthograde to slight clinograde vertical distribution (Plate 16). During the period of 2003 through 2007, dissolved oxygen concentrations in the hypolimnion remained at or above 5 mg/l through the summer (Plate 16).

5.2.2.1.4 Water Clarity

5.2.2.1.4.1 Secchi Transparency

Figure 5.2 displays a box plot of the Secchi depth transparencies measured at monitoring sites FTPLK1772A, FTPLK1805DW, and FTPLKBDCA02 during the period 2004 through 2007. Secchi depth transparency was observably lower in the upper reaches of both arms of the reservoir (i.e., sites FTPLK1805DW and FTPLKBDCA02) as compared to the near-dam conditions (i.e., site FTPLK1772A).

5.2.2.1.4.2 Turbidity

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Given the low chlorophyll *a* concentrations monitored in Fort Peck Reservoir (Plates 1-6), turbidity in the reservoir appears to be largely due to suspended inorganic material. Monthly (i.e., June, July, and September) longitudinal contour plots were prepared from the depth-profile

turbidity measurements taken at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and, FTPNFMORR1 during 2007 (Plates 17 through 19). As seen in Plates 17 through 19, turbidity levels in Fort Peck Reservoir vary longitudinally from the dam to reservoir's upper reaches and vertically from the reservoir surface to the bottom. Turbidity levels are noticeably higher in the upper reaches of the Missouri River Arm of the reservoir as compared to the area near the dam. This is attributed to the turbid conditions of the inflowing Missouri River.

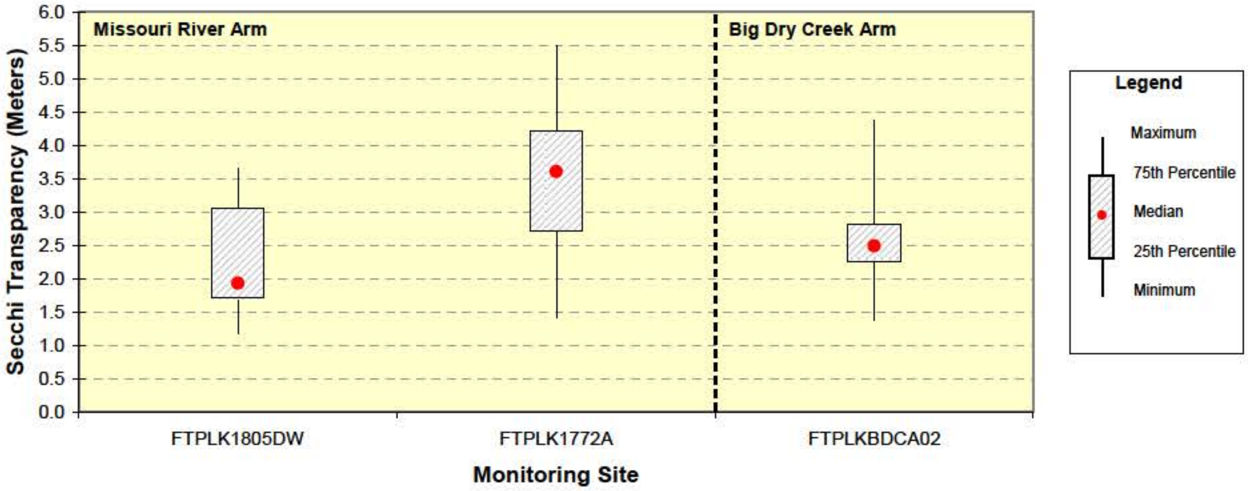

Figure 5.2. Box plot of Secchi transparencies measured in Fort Peck Reservoir during the period 2004 through 2007.

5.2.2.1.5 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Fort Peck Reservoir during the summer over the past 4 years at the near-dam, deepwater area (i.e., site FTPLK1772A) were compared. Near-surface samples were taken to be samples collected within 2 meters of the reservoir surface, and near bottom-samples were taken to be samples collected within 2 meters of the reservoir bottom. Box plots were used to display the distribution of the paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 20). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. The only parameter that significantly varied between the surface and bottom was water temperature (Plate 20).

5.2.2.1.6 Reservoir Trophic Status

Trophic State Index (TSI) values for Fort Peck Reservoir were calculated from monitoring data collected during the past 4 years (Table 5.2). The calculated TSI values indicate that the region of the reservoir represented by the monitored sites is in a mesotrophic state.

Table 5.2. Mean Trophic State Index (TSI) values calculated for Fort Peck Reservoir. TSI values are based on monitoring at the identified four sites during the 4-year period 2004 through 2007.

Monitoring Site	Mean – TSI (Secchi Depth)	Mean – TSI (Total Phos.)	Mean – TSI (Chlorophyll)	Mean – TSI (Average)
FTPLK1772A	42	52	41	45
FTPLK1805DW	49	54	48	51
FTPLKBDCA02	47	50	43	47

Note: See Section 4.1.4 for discussion of TSI calculation.

5.2.2.1.7 Phytoplankton Community

Phytoplankton grab samples were collected from Fort Peck Reservoir at three sites (i.e., FTPLK1772A, FTPLK1805DW, and FTPLKBDCA02) during the spring and summer of the 4-year period 2004 through 2007 (Plates 21-23). The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta/Cryptophyta/Cyanobacteria/Pyrrophyta/ > Chrysophyta > Euglenophyta. The diatoms were generally the most abundant algae throughout the entire sampling period based on percent composition (Plates 21-23). The Shannon-Weaver genera diversity indices calculated for the phytoplankton samples collected at the three sites ranged from 0.40 to 2.28 and averaged 1.51 at site FTPLK1772A, 1.87 at site FTPLK1805DW, and 1.56 at site FTPLKBDCA02. Dominant phytoplankton genera sampled at the three sites in 2007 (i.e., genera comprising more than 10% of the total biovolume of at least one sample collected in 2007) included the Bacillariophyta *Asterionella*, *Aulacoseria*, *Fragilaria*,*Stephanodiscus*, and *Surirella*; Chlorophyta *Pyramichlamys*; Chrysophyta *Dinobryon*; Cryptophyta *Rhodomonas*; Cyanobacteria *Anabaena* and *Anabaenopsis*; and Pyrrophyta *Ceratium*. No concentrations of microcystins above 1 ug/l were monitored in Fort Peck Reservoir during 2005 through 2007.

5.2.2.2 Water Quality Trends (1980 through 2007)

Water quality trends over the 28-year period of 1980 to 2007 were determined for Fort Peck Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through October at the near-dam, ambient monitoring site (i.e., site FTPLK1772A). Plate 24 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. For the assessment period, it appears that Fort Peck Reservoir exhibited slightly decreasing transparency (i.e., decreasing Secchi depth) and slightly increasing levels of total phosphorus. There was no observed trend in chlorophyll *a* levels. Over the 27-year period, the reservoir has generally remained in a mesotrophic state. However, there appears to be a slight trend in the calculated TSI values that indicate the reservoir may be moving towards a moderately eutrophic condition (Plate 24).

5.2.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI RIVER INFLOW TO FORT PECK RESERVOIR

5.2.3.1 Statistical Summary and Water Quality Standards Attainment

The water quality conditions that were monitored in the Missouri River near Landusky, MT (i.e., site FTPNFMORR1) monthly from May through September during the 4-year period 2004 through 2007

are summarized in Plate 25. A review of these results indicated no major water quality concerns. However, it is noted that very high levels of total iron and manganese were monitored. This is believed to be a natural condition associated with the geology and soils of the region.

5.2.3.2 Missouri River Inflow Nutrient Flux Conditions

Nutrient flux rates for the Missouri River inflow to Fort Peck Reservoir over the last 4 years were calculated based on water quality samples collected near Landusky, MT (i.e. site FTPNFMORR1) and the estimated instantaneous flow conditions at the time of sample collection (Table 5.3). The maximum nutrient flux rates are attributed to greater nonpoint-source nutrient loadings associated with runoff conditions.

Table 5.3. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River near Landusky, MT (i.e., site FTPNFMORR1) during May through September over the 4-year period 2004 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	17	17	17	17	16	16
Mean	0.028	0.274	0.012	0.139	0.004	0.598
Median	0.022	0.119	0.004	0.027	0.001	0.444
Minimum	n.d.	0.035	n.d.	0.003	n.d.	0.270
Maximum	0.103	1.324	0.010	1.055	0.005	1.294

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 7,286 cfs, median = 7,210 cfs, minimum = 3,978 cfs, and maximum = 12,200 cfs.

5.2.3.3 Continuous Water Temperature Monitoring of the Missouri River at the USGS Gaging Station near Landusky, MT

Through an agreement with the U.S. Geological Survey (USGS), a water temperature monitoring probe was added to the USGS's gage (06115200) on the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1). Beginning in October 2004, hourly water temperature measurements were recorded at the site. Plates 26 and 27, respectively, plot mean daily water temperature and river discharge determined for 2005 and 2006. No water temperature data were collected in 2007. The temperature monitoring probe became inoperable, and the USGS was unable to repair it during 2007. Plate 28 plots the mean daily river discharge for 2007.

5.2.4 WATER QUALITY AT THE FORT PECK POWERPLANT

5.2.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 29 summarizes the water quality conditions that were monitored from water discharged through Fort Peck Dam during the 4-year period of 2004 through 2007. A review of these results indicated only one possible water quality concern regarding dissolved oxygen. The 1-day dissolved oxygen minimum criterion of 8.0 mg/l for the protection of coldwater B-2 early life stages was not met for 18% of the dissolved oxygen measurements. The 8.0 mg/l criterion is a water column concentration recommended to achieve an in-gravel dissolved oxygen concentrations of 5.0 mg/l. For species that have early life stages exposed directly to the water column, the criterion is 5.0 mg/l. No dissolved oxygen

measurements were below 5.0 mg/l. The B-2 classification of the Missouri River downstream of Fort Peck Dam only extends to the confluence of the Milk River, a distance of approximately 10 miles. Given the coldwater species and recruitment present, the 5.0 mg/l water column dissolved criterion may be appropriate for this reach. Also, the dissolved oxygen measurements below 8.0 mg/l tended to occur in later summer when the effects on early life stages are likely to be reduced. Therefore, the observed dissolved oxygen measurements below 8.0 mg/l are not believed to be a significant water quality concern at this time.

5.2.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time-series plots for temperature, dissolved oxygen, and dam discharge monitored at the Fort Peck powerplant during the 4-year period of 2004 through 2007 were constructed. Water temperatures showed seasonal warming and cooling through each calendar year (Plates 30 - 37). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall (Plates 38 - 45). The lowest dissolved oxygen levels occurred during the late summer/early fall period. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The decreasing dissolved oxygen in the July to September period is attributed to ongoing degradation of dissolved oxygen in the lower hypolimnion as the summer progressed. Water is withdrawn from Fort Peck Reservoir into the dam's power tunnels approximately 65 feet above the reservoir bottom. There appeared to be little correlation between discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 30 - 45).

5.2.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Fort Peck Reservoir

Plates 46 and 47, respectively, plot the mean daily water temperatures monitored at the Missouri River near Landusky, MT (site FTPNFMORR1) and the Fort Peck Dam powerplant (site FTPPP1) for 2005 and 2006. Inflow temperatures of the Missouri River to Fort Peck Reservoir are generally warmer than the outflow temperatures of Fort Peck Dam during the period of March through August (Plates 46 and 47). Outflow temperatures of the Fort Peck Dam discharge are generally warmer than the inflow temperatures of the Missouri River during the period of September through February (Plates 46 and 47). A maximum temperature difference occurs in the summer when the Missouri River inflow temperature is about 10°C warmer than the Fort Peck Dam outflow temperature. A plot for 2007 comparing water temperatures of the Missouri River inflow and outflow to Fort Peck Reservoir was not possible because water temperatures were not monitored at the USGS gage near Landusky, MT (06115200) in 2007 due to equipment problems.

5.2.5 WATER QUALITY IN THE MISSOURI RIVER DOWNSTREAM FROM FORT PECK DAM

Water temperatures have been monitored in the Missouri River downstream of Fort Peck Dam over the past several years as part of a multi-agency effort to study the pallid sturgeon population in the Missouri and Yellowstone Rivers. Two sites on the Missouri River that have been monitored by the USGS under this effort are the Fort Peck Dam tailwaters (i.e., approximately 5 miles downstream of Fort Peck Dam) and Frazer Rapids (approximately 25 miles downstream of Fort Peck Dam).

The water temperatures monitored at the Fort Peck Dam powerplant during the period 2004 through 2007 were compared to the Missouri River water temperatures monitored by the USGS at their tailwaters and Frazer Rapids sites. Plates 48 through 51, respectively, plot mean daily water temperatures monitored at the three sites and the mean daily discharge of Fort Peck Dam from May through October during 2004, 2005, 2006, and 2007. During the 4 years, water temperatures monitored at the Fort Peck

Dam powerplant from June through August were generally 2°C cooler than the water temperatures monitored in the Missouri River at the Fort Peck Dam tailwaters site, and 4°C cooler than the water temperatures monitored in the Missouri River at Frazer Rapids (Plates 48 - 51). During early to mid-September of each year, water temperatures monitored at the three sites were somewhat similar. In early September the water temperatures monitored at the Fort Peck Dam powerplant exhibited pronounced warming. This is attributed to the cooling and downward expansion of the epilimnion in Fort Peck Reservoir as "fall turnover" of the reservoir approached. It appears that in early September the downward expanding epilimnion intersected with the upper reaches of "withdrawal zone" of the intake for the power tunnels. This resulted in warmer epilimnetic warmer being captured in the reservoir and discharged through Fort Peck Dam. During late-September to early October, water temperatures monitored at the Fort Peck powerplant were generally warmer than those monitored in the Missouri River downstream of Fort Peck Dam. This is attributed to the slower heat loss from Fort Peck Reservoir than the Missouri River in early fall. Warmer water from the epilimnion of Fort Peck Reservoir is discharged through Fort Peck Dam that cools as it moves down the Missouri River. It is during this time period that the relationship of warmer water temperatures occurring in the Missouri River at Frazer Rapids and cooler water temperatures occurring at the Fort Peck Dam powerplant reverses (Plates 48 - 51).

5.3 GARRISON

5.3.1 BACKGROUND INFORMATION

5.3.1.1 Project Overview

Garrison Dam is located in central North Dakota on the Missouri River at RM 1389.9, about 75 miles northwest of Bismarck, ND and 11 miles south of the town of Garrison, ND. Construction of the project began in 1946, and closure of Garrison Dam in 1953 resulted in the formation of Garrison Reservoir (Lake Sakakawea), which is the largest Corps reservoir in the United States. When full, the reservoir is 178 miles long, up to 6 miles wide, and has 1,884 miles of shoreline. The reservoir contains almost a third of the total storage capacity of the Mainstem System, nearly 24 million acre-ft (MAF). Table 5.4 summarizes how the surface area, volume, mean depth, and retention time of Garrison Reservoir vary with pool elevations. Due to ongoing drought conditions, the reservoir, at the end of December 2007, was at pool elevation 1810.9 ft-msl. This is 26.6 feet below the top of the Carryover Multiple Use Zone (1837.5 ft-msl). Major inflows to the reservoir are the Missouri, Yellowstone, and Little Missouri Rivers. Water discharged through Garrison Dam for power production is withdrawn from Garrison Reservoir at elevation 1672 ft-msl, approximately 2 feet above the reservoir bottom.

The reservoir and dam are authorized for the purposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. Over the period 1967 through 2007, the five generating units at Garrison Dam have produced an annual average 2.293 MWh of electricity, which has a current revenue value of approximately $37 million. The ongoing drought in the western United States has curtailed releases and power production at the Mainstem System projects, including Garrison. Power production at the Garrison Dam generating units averaged an annual 1.506 MWh over the 5-year period 2003 through 2007 Habitat for two endangered species, pallid sturgeon and interior least tern, and one threatened species, piping plover, occurs within the project area. The reservoir is used as a water supply by some individual cabins and by the towns of Four Bears, Mandaree, Park City, Parshall, Riverdale, Trenton, Twin Buttes, and Williston, ND. Garrison Reservoir is an important recreational resource and a major visitor destination in North Dakota.

Table 5.4. Surface area, volume, mean depth, and retention time of Garrison Reservoir at different pool elevations.

Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
1855	384,480	24,203,180	63.0	1.55
1850	364,265	22,331,620	61.3	1.43
1845	344,460	20,558,360	59.7	1.32
1840	320,600	18,893,560	58.9	1.21
1835	296,210	17,355,220	58.6	1.11
1830	280,520	15,916,490	56.7	1.02
1825	263,525	14,556,980	55.2	0.93
1820	249,665	13,275,410	53.2	0.85
1815	235,600	12,061,430	51.2	0.77
1810	219,955	10,921,980	49.7	0.70
1805	204,453	9,861,138	48.2	0.63
1800	188,998	8,877,219	47.0	0.57
1795	173,070	7,973,682	46.1	0.51
1790	161,295	7,139,184	44.3	0.46
1785	148,759	6,364,791	42.8	0.41
1780	138,809	5,646,736	40.7	0.36
1775	128,261	4,979,890	38.8	0.32

Average Annual Inflow (1967 through 2007) = 16.31 Million Acre-Feet
Average Annual Outflow: (1967 through 2007) = 15.57 Million Acre-Feet
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 1854-1850 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 1850-1837.5 ft-msl), Carryover Multiple Use Zone (elev. 1837.5-1775 ft-msl), and Permanent Pool Zone (elev. 1775-1670 ft-msl). All elevations are in the NGVD 29 datum.

5.3.1.2 Water Quality Standards Classifications and Section 303(d) Listings

5.3.1.2.1 Garrison Reservoir

Pursuant to the Federal CWA, the State of North Dakota has designated Garrison Reservoir as a Class 1 lake. As such, the reservoir is to be suitable for the propagation and/or protection of a coldwater fishery (i.e., salmonid fishes and associated aquatic biota); swimming, boating, and other water recreation; irrigation; stock watering; wildlife; and municipal or domestic use after appropriate treatment. Also pursuant to the Federal CWA, the State of North Dakota has placed the reservoir on the State's Section 303(d) list of impaired waters citing impairment to the uses of fish and other aquatic biota and fish consumption due to the pollutants/stressors of low dissolved oxygen, water temperature, and methyl-mercury. The State of North Dakota has issued a fish consumption advisory for Garrison Reservoir due to mercury concerns.

5.3.1.2.2 Missouri River Downstream of Garrison Dam

The State of North Dakota has designated the entire Missouri River as a Class I stream. As such, the river is to be suitable for the propagation and/or protection of resident fish species and other aquatic biota; swimming, boating, and other water recreation; irrigation; stock watering; wildlife; and municipal or domestic use after appropriate treatment. The river has not been placed on the State's Section 303(d) list of impaired waters. The State of North Dakota has issued a fish consumption advisory for the Missouri River due to mercury concerns.

5.3.1.3 <u>Management of Coldwater Habitat in Garrison Reservoir</u>

5.3.1.3.1 Coldwater Habitat Criteria – Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen levels are primary water quality factors that determine the suitability of water for coldwater aquatic life. Water quality standards for the protection of aquatic life (i.e., water temperature and dissolved oxygen criteria) usually include different levels of protection based on habitat types, life stages (i.e., eggs, fry, juvenile, and adults), and acute and chronic effects. The State of North Dakota has not specifically promulgated numeric temperature criteria for the protection of coldwater aquatic life in the State's water quality standards. However, as part of the State's fishery management program, a water temperature of ≤15°C has been identified as optimal for managing the coldwater fishery habitat of Garrison Reservoir. The State's water quality standards specify a dissolved oxygen criteria of ≥ 5 mg/l for the protection of aquatic life in Garrison Reservoir. Thus, a water temperature of ≤15°C and a dissolved oxygen concentration of ≥ 5 mg/l are used to define optimal coldwater habitat for Garrison Reservoir.

5.3.1.3.2 Implementation of Short-term Water Quality Management Measures to Preserve Coldwater Habitat in Garrison Reservoir

The most crucial period for the support of coldwater habitat in Garrison Reservoir is when it begins to cool in late summer. As the thermocline moves deeper, the volume of the coldwater hypolimnion continues to decrease while the expanding epilimnion has not cooled enough to be supportive of coldwater habitat. At the same time, hypolimnetic dissolved oxygen concentrations are approaching their maximum degradation and low dissolved oxygen levels are moving upward from the reservoir bottom and pinching off coldwater habitat from below. This situation continues to worsen until the epilimnion cools enough to be supportive of coldwater habitat and the reservoir eventually experiences fall turnover. The volume of the hypolimnion (i.e., of coldwater habitat) occurring in Garrison Reservoir during the summer decreases with lower pool levels.

As drought conditions persisted in early 2005, water levels in Garrison Reservoir had fallen to a record low pool elevation of 1805.8 feet-msl on May 12, 2005. At that time it was felt that unless emergency water quality management measures were implemented in 2005 to preserve the coldwater habitat in the reservoir, the recreational sport fishery would likely be adversely impacted. The reduction of coldwater habitat is exacerbated by withdrawals through the Garrison Dam intake structure. Because the invert elevation of the intake portals to the Garrison Dam power tunnels (i.e., penstocks) is 2 feet above the reservoir bottom, water drawn through the penstocks comes largely from the lower depths of the reservoir. Thus, during the summer thermal-stratification period, water is largely drawn from the hypolimnetic volume of Garrison Reservoir. Three short-term water quality management measures were identified for implementation in 2005 in an effort to preserve the coldwater habitat in the reservoir. These measures, which were implemented at Garrison Dam, included: 1) application of a plywood barrier to the dam's intake trash racks, 2) utilization of head gates to restrict the opening to the dam's power tunnels, and 3) modification of the daily flow cycle and minimum flow releases from the dam. The three implemented water quality management measures were targeted at drawing water into the dam from higher elevations within Garrison Reservoir.

5.3.1.3.2.1 Application of a Plywood Barrier to the Dam's Intake Trash Racks

The five power tunnels at Garrison Dam are screened at the upstream end of the water passage by trash racks. These trash racks prevent large objects from entering the penstocks and causing serious damage to the wicket gates and turbine. Each of the five Units has two intake passages for a total of ten intakes. The trash rack for each of the ten intakes consists of seven separate frame sections. The trash

rack fits into the trash rack slots at the front of the intake passage piers. A hook for each rack is fixed to the top of the frame. A lifting beam and mobile crane is used to raise and lower each trash rack.

The existing trash racks were modified to raise the elevation where water was withdrawn from Garrison Reservoir. The trash rack modification consisted of installing plywood sheathing on the upstream side of the existing trash rack grates on the passages to Units 2 and 3. The plywood sheathing covered the lower 48 feet of the trash racks (i.e., approximately elevation 1672 to 1720 ft-msl) with the exception of a 3-inch slot at the very bottom for passing sediments. The plywood installation was completed on the trash racks to Unit 3 on July 15, 2005 and on the trash racks to Unit 2 on July 20, 2005. The plywood was inspected with an underwater camera in the spring of 2006 and determined to still be in good condition.

In mid-May 2007, attempts were made to install plywood barriers to the trash racks of Unit 1. Due to a large tree at the bottom of the east intake to Unit 1, plywood could not be installed on all the trash racks. The bottom trash rack on the east side of Unit 1 could not be removed and did not receive a plywood barrier. There are 2½ trash racks with plywood barriers on the east side of Unit 1 and 3½ trash racks with plywood on the west side. Therefore, a plywood barrier existed on the west side of Unit 1 from elevation 1672 to 1720 ft-msl, and on the east side of Unit 1 from elevation 1688 to 1720 ft-msl. The plywood for the trash racks for Unit 1 was installed and the Unit returned to service on May 19, 2007. The plywood barriers were still in place on the trash racks of Units 1, 2, and 3 as of December 31, 2007.

5.3.1.3.2.2 Utilization of Head Gates to Restrict the Opening to the Dam's Power Tunnels

Each of the intake passages to all five power tunnels have operational head gates that control flow into the penstocks. It was reasoned that lowering one of the two head gates to block a single passage to the power tunnel should increase the velocity of water drawn into the power tunnel, given the total flow through the power tunnel remained the same. Increasing the velocity of the water drawn into the intake could pull water from a higher elevation in Garrison Reservoir and possibly help maintain the reservoir's deeper, colder volume. To implement this measure in 2006, single head gates on the passages to Units 1 and 4 were lowered on July 5, 2006. Similarly in 2007, single head gates on the passages to Units 1 and 4 were lowered on May 30, 2007 and were raised on October 2, 2007.

5.3.1.3.2.3 Modification of Daily Flow Cycle and Maximum and Minimum Flow Releases

Past water quality monitoring at the Garrison Dam powerhouse indicated that the vertical extent of the withdrawal zone in Garrison Reservoir during summer thermal stratification was dependent on the discharge rate of the dam. Warmer water high in dissolved oxygen was drawn down from higher elevations in the reservoir under higher discharge rates, and colder water low in dissolved oxygen was drawn from the lower depths of the reservoir under lower discharge rates. The influence of the dam's discharge rate on the reservoir withdrawal zone is believed to be partly attributed to the design of the intake structure and submerged intake channel.

To the extent possible, flow releases from Garrison Dam during 2005, 2006, and 2007 were modified to try to maximize the water drawn from higher elevations and minimize the water drawn from lower elevations in Garrison Reservoir. The following two flow release modifications were pursued: 1) daily flow releases should be in either a maximum or minimum mode; and 2) minimum flows should be discharged through Units 2 and 3, which have the "full" plywood barriers in place. Unit 1, with a "partial" plywood barrier, was used as a back-up to Units 2 and 3 for discharging minimum flows.

5.3.1.3.3 Performance Assessment Report

A more detailed discussion of the implementation of the short-term water quality management measures and their effects through 2005 is given in the Performance Assessment Report, "Garrison Cold Water Fishery Performance Assessment" (USACE, 2006b).

5.3.1.4 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Garrison Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the inflow to and outflow from the reservoir. A 3-year intensive water quality survey was completed at the Garrison Project in 2005 and the findings of the intensive survey are available in the separate report, "Water Quality Conditions Monitored at the Corps' Garrison Project in North Dakota during the 3-Year period 2003 through 2005" (USACE, 2006c). Figure 5.3 shows the location of sites at the Garrison Project that have been monitored for water quality during the past 5 years (i.e., 2003 through 2007). The near-dam location (i.e., site GARLK1390A) has been continuously monitored since 1980.

5.3.2 WATER QUALITY IN GARRISON RESERVOIR

5.3.2.1 Existing Water Quality Conditions (2003 through 2007)

5.3.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Water quality conditions that were monitored in Garrison Reservoir at sites GARLK1390A, GARLK1399DW, GARLK1412DW, GARLK1428DW, GARLK1445DW, GARLK1454DW, GARLK1481DW, and GARLK1493DW from May through September during the 5-year period 2003 through 2007 are summarized in Plates 52 through 59. A review of these results indicated possible water quality concerns regarding water temperature for the support of optimal coldwater habitat and dissolved oxygen levels for the support of aquatic biota. Water temperatures in the epilimnion of the reservoir regularly exceed 15°C in the summer, while temperatures in the hypolimnion are less than 15°C. Dissolved oxygen levels in the hypolimnion continually degrade along the reservoir bottom as summer progresses and fall below 5 mg/l in late summer. Low dissolved oxygen conditions occur in the upstream reaches of the hypolimnion first and progress towards the dam. As the summer progresses, low dissolved oxygen conditions move up from the reservoir bottom into the mid and upper reaches of the hypolimnion. This pinching off of coldwater habitat threatens the occurrence of optimal coldwater habitat in the reservoir, especially under low pool levels during drought conditions. The lowest dissolved oxygen concentration measured at the eight sites was 1.0 mg/l and occurred at site GARLK1445DW on August 29, 2006.

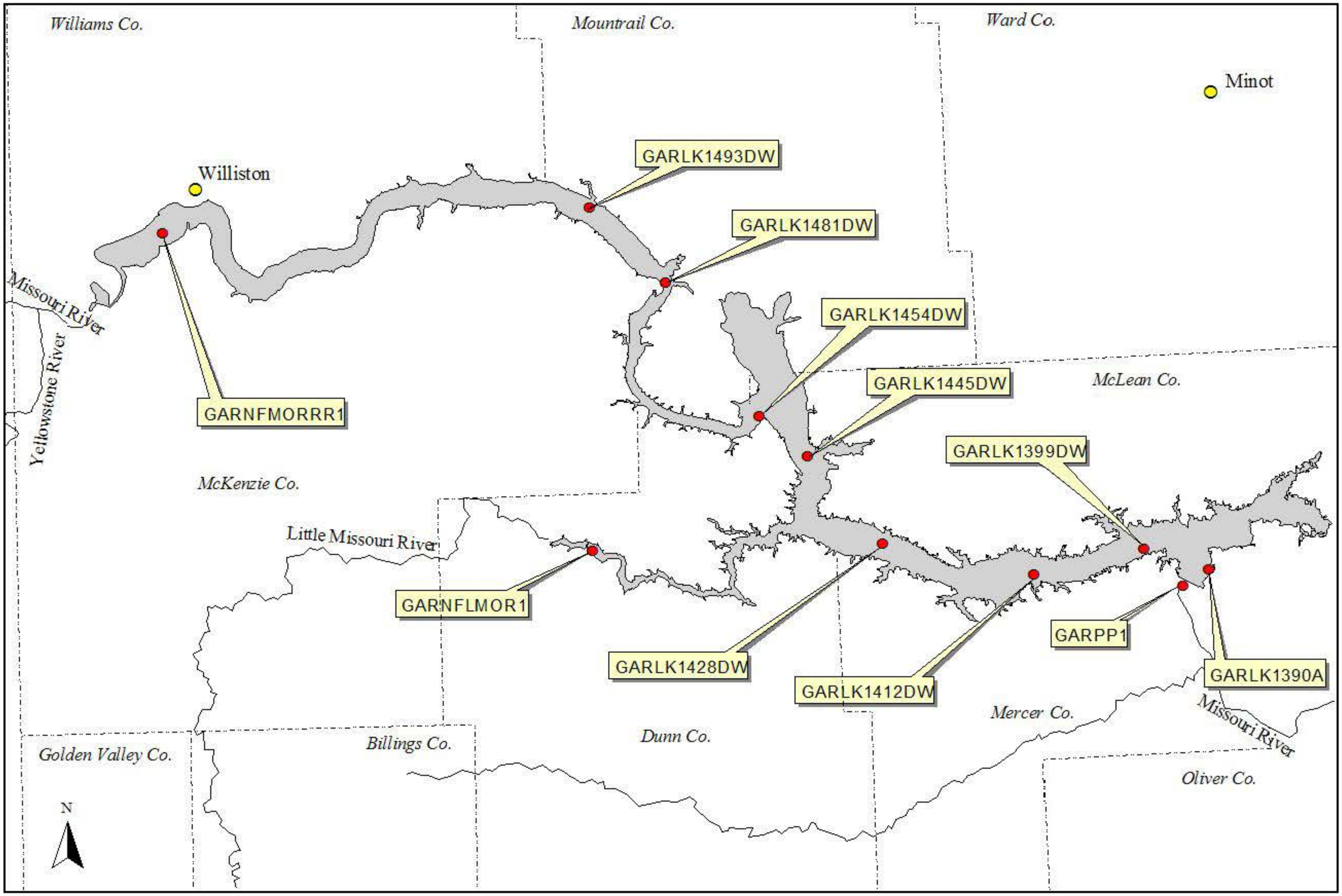

Figure 5.3. Location of sites where water quality monitoring was conducted by the District at the Garrison Project during the period 2003 through 2007.

5.3.2.1.2 Summer Thermal Stratification

5.3.2.1.2.1 2006 Monthly Longitudinal Temperature Contour Plots

Summer thermal stratification of Garrison Reservoir during 2007 is described by the monthly longitudinal temperature contour plots based on depth-profile temperature measurements taken in May, June, July, August, and September (Plates 60 - 65). The contour plots were constructed along the length of the reservoir. As seen in Plates 60 through 65, water temperature in Garrison Reservoir varies longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom. The near-surface water in the upper reaches of the reservoir warms up sooner in the spring than the near-surface water near the dam (Plates 60 and 61). By mid-summer a strong thermocline becomes established in the lower reaches of the reservoir, and the near-surface waters of the entire reservoir above the thermocline are a fairly uniform temperature (Plates 62 and 63). As the near-surface waters of the reservoir cool in the late summer, the thermocline is pushed deeper and these wind-mixed upper waters are fairly uniform in temperature (Plates 64 and 65). The vertical variation in temperature is most prevalent in the deeper area of the reservoir towards the dam where a strong thermocline becomes established during the summer. The shallower upper reaches of Garrison Reservoir do not exhibit much vertical variation of temperature during mid to late summer as wind action allows for complete mixing of the water column.

5.3.2.1.2.2 Near-Dam Temperature Depth-Profile Plots

Existing summer thermal stratification of Garrison Reservoir at the deep water area near the dam is described by the depth-profile temperature plots measured over the past 5 years. Depth-profile temperature plots measured during the summer were compiled (Plate 66). The plotted depth-profile measurements indicate that a significant temperature-depth gradient occurs in Garrison Reservoir in the near-dam lacustrine area during the summer, and a thermocline becomes established at a depth of about 25 meters (Plates 63 and 66).

5.3.2.1.3 Summer Dissolved Oxygen Conditions

5.3.2.1.3.1 2006 Monthly Longitudinal Dissolved Oxygen Contour Plots

Dissolved oxygen contour plots were constructed along the length of Garrison Reservoir based on depth-profile measurements taken in May, June, July, August, and September of 2007 (Plates 67 - 72). During the summer of 2007, dissolved oxygen conditions in Garrison Reservoir varied longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom (Plates 67 - 72). Dissolved oxygen levels below 5 mg/l first appeared near the reservoir bottom in the upper-middle reaches of the reservoir in July (Plate 69). As the summer progressed, dissolved oxygen concentrations below 5 mg/l moved along the reservoir bottom to the area near the dam (Plates 69 - 71). By late summer, dissolved oxygen levels below 5 mg/l only occurred near the bottom in the deeper lacustrine area of the reservoir, as the near-bottom dissolved oxygen concentrations in the upper-middle reaches of the reservoir had recovered to near saturation levels (Plate 71). By the end of September, the area of Garrison Reservoir near the dam had experienced fall turnover and dissolved oxygen levels recovered to near saturation concentrations (Plate 72). The earlier occurrence of low dissolved oxygen concentrations in the near-bottom water of the upper-middle reaches of Garrison Reservoir is attributed to the increased allochthonous organic loading in the transition zone of the reservoir and the lesser hypolimnetic volume available for assimilation of the oxygen demand. As this material decomposes, a "pool" of water with low dissolved oxygen levels accumulates near the bottom in this area of the reservoir. Decomposition of autochthonous organic matter also occurs in the lacustrine zone and results in dissolved oxygen degradation as the summer progresses, although at a slower rate than what occurs in

the transition zone. The recovery of near-bottom dissolved oxygen concentrations to saturation levels takes longer in the lacustrine zone nearer the dam because of the longer time needed for thermal stratification to breakdown and mixing within the water column to occur in the deeper water. The near-bottom location of the power tunnel intakes at the dam could also seemingly result in an interflow along the reservoir bottom that could promote the movement of oxygen-demanding material and low dissolved oxygen water from the upper-middle reaches of the reservoir to the dam. Any interflow affect would likely increase as pool elevations drop and the reservoir's retention time decreases.

5.3.2.1.3.2 Near-Dam Dissolved Oxygen Depth-Profile Plots

Existing summer dissolved oxygen conditions in Garrison Reservoir at the deep water area near the dam are described by the depth-profile dissolved oxygen plots measured over the past 5 years. Depth-profile dissolved oxygen plots measured during the summer were compiled (Plate 73). Dissolved oxygen levels exhibited a significant gradient with depth and tended toward a clinograde vertical distribution (Plate 73). During the period of 2003 through 2007, dissolved oxygen concentrations in the lower hypolimnion fell below 5 mg/l as the summer progressed, with the lowest levels occurring in late-August and September. The lowest dissolved oxygen concentration measured at this site over the past 5 years was 3.8 mg/l.

5.3.2.1.4 Water Clarity

5.3.2.1.4.1 Secchi Transparency

Figure 5.4 displays a box plot of the Secchi depth transparencies measured along Garrison Reservoir at the four sites GARLK1481DW, GARLK1445DW, GARLK1412DW, and GARLK1390A during the 5-year period 2003 through 2007. Secchi depth transparency significantly increased in a downstream direction between sites GARLK1481DW, GARLK1445DW, and GARLK1412DW (Figure 5.4). This is attributed to suspended sediment in the inflowing Missouri River settling out in the reservoir as current velocities slow. The surface waters near Garrison Dam are significantly clearer than the upstream regions of the reservoir. Under the conditions that were monitored during the 2003 to 2007 period, it appears that site GARLK1481DW was in the riverine zone; site GARLK1445DW was in the transition zone; and sites GARLK1412DW and GARLK1390A were in the lacustrine zone of the reservoir.

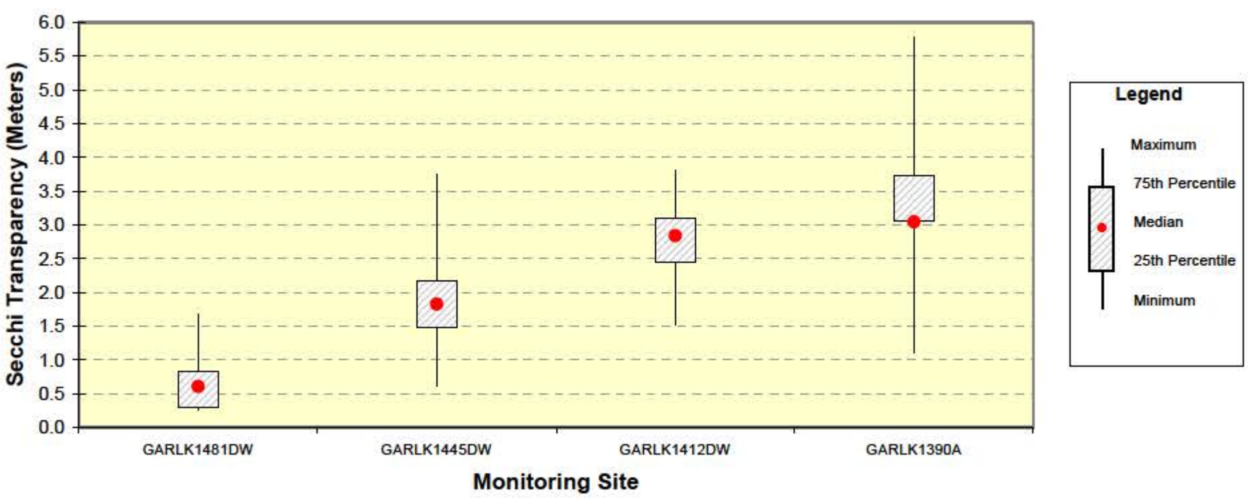

Figure 5.4. Box plot of Secchi transparencies measured in Garrison Reservoir during the period 2003 through 2007. (Note: monitoring sites are oriented on the x-axis in an upstream to downstream direction.)

5.3.2.1.4.2 Turbidity

Given the low chlorophyll *a* concentrations monitored in Garrison Reservoir (Plates 52-59), turbidity in the reservoir appears to be largely due to suspended inorganic material. Monthly (i.e., May, June, July, August, and September) longitudinal contour plots were prepared from the depth-profile turbidity measurements taken at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 during 2007 (Plates 74 - 78). As seen in Plates 74 through 78, turbidity levels in Garrison Reservoir vary longitudinally from the dam to reservoir's upper reaches and vertically from the reservoir surface to the bottom. Turbidity levels are significantly higher in the upper reaches of the reservoir as compared to the area near the dam. This is attributed to the turbid conditions of the inflowing Missouri River. It also appears that turbidity plumes may move through Garrison Reservoir as interflows; especially along the bottom. This may be attributed to colder inflowing snowmelt runoff, with higher turbidity levels, flowing underneath warmer surface waters in Garrison Reservoir as an interflow along the bottom.

5.3.2.1.5 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Garrison Reservoir at the near-dam, deepwater area (i.e., site GARLK1390A) during the 5-year period 2003 through 2007 were compared. Near-surface samples were taken to be samples collected within 2 meters of the reservoir surface, and near bottom-samples were taken to be samples collected within 2 meters of the reservoir bottom. Box plots were used to display the distribution of paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 79). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. The only parameter that significantly varied between the surface and bottom was water temperature; however, dissolved oxygen was nearly significantly different (Plate 79). Both temperature and dissolved oxygen were lower near the reservoir bottom.

5.3.2.1.6 Reservoir Trophic Status

Trophic State Index (TSI) values for Garrison Reservoir were calculated from monitoring data collected during the 5-year period 2003 through 2007 (Table 5.5). The calculated TSI values indicate that the lacustrine zone of the reservoir (i.e., sites GARLK1390A and GARLK1412DW) is mesotrophic, the transition zone (i.e., site GARLK1445DW) is moderately eutrophic, and the riverine zone (i.e., site GARLK1481DW) is eutrophic. However, it is noted that the calculated average TSI value for the riverine zone is greatly influenced by the low water clarity in this part of the reservoir. This lack of water clarity is largely attributed to suspended inorganic material delivered to the reservoir by the Missouri River. Thus, the higher TSI values in the riverine zone seemingly are not indicative of increased algal growth associated with nutrient enrichment.

Table 5.5. Mean Trophic State Index (TSI) values calculated for Garrison Reservoir. TSI values are based on monitoring at the identified four sites during the 5-year period 2003 through 2007.

Monitoring Site	Mean – TSI (Secchi Depth)	Mean – TSI (Total Phos.)	Mean – TSI (Chlorophyll)	Mean – TSI (Average)
GARLK1390A	45	53	44	47
GARLK1412DW	46	51	45	47
GARLK1445DW	52	52	50	51
GARLK1481DW	68	55	53	61

Note: See Section 4.1.4 for discussion of TSI calculation.

5.3.2.1.7 Phytoplankton Community

Phytoplankton grab samples were collected from Garrison Reservoir at four sites (i.e., GARLK1390A, GARLK1412DW, GARLK1445DW, and GARLK1481DW) during the spring and summer of the 4-year period 2004 through 2007 (Plates 80 - 83). The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta > Cryptophyta/Cyanobacteria/Pyrrophyta > Chrysophyta > Euglenophyta. The diatoms were generally the most abundant algae throughout the entire sampling period based on percent composition (Plates 80 - 83). The Shannon-Weaver genera diversity indices calculated for the phytoplankton samples collected at the four sites ranged from 0.41 to 2.69 and averaged 1.40 at site GARLK1390A, 1.57 at site GARLK1412DW, 1.50 at site GARLK1445DW, and 1.76 at site GARLK1481DW. Dominant phytoplankton genera sampled at the three sites in 2007 (i.e., genera comprising more than 10% of the total biovolume of at least one sample collected in 2007) included the Bacillariophyta *Asterionella*, *Aulacoseria, Fragilaria, and Stephanodiscus*; Chlorophyta *Pyramichlamys*; Chrysophyta *Dinobryon*; Cryptophyta *Rhodomonas*; Cyanobacteria *Anabaena* and *Anabaenopsis*; and Pyrrophyta *Ceratium*. No concentrations of microcystins above 1 ug/l were monitored in Garrison Reservoir during 2005 through 2007.

5.3.2.2 <u>Water Quality Trends (1980 through 2007)</u>

Water quality trends over the 28-year period of 1980 through 2007 were determined for Garrison Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through October at the near-dam, ambient monitoring site (i.e., site GARLK1390A). Plate 84 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. For the assessment period, it appears that the reservoir exhibited slightly increasing concentrations of total phosphorus. There was no observed trend in transparency (i.e. Secchi depth) or chlorophyll *a*. Over the 28-year period, Garrison Reservoir has generally remained in a mesotrophic state with calculated TSI values showing no observable trend (Plate 84).

5.3.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI RIVER INFLOW TO GARRISON RESERVOIR

5.3.3.1 <u>Statistical Summary and Comparison to Applicable Water Quality Standards Criteria</u>

The water quality conditions that were monitored in the Missouri River near Williston, ND (i.e., site GARNFMORRR1) monthly from May through September during the 5-year period 2003 through 2007 are summarized in Plate 85. A review of these results indicated no major water quality concerns. However, it is noted that very high levels of total iron were monitored. This is believed to be a natural condition associated with the geology and soils of the region.

5.3.3.2 <u>Missouri River Inflow Nutrient Flux Conditions</u>

Nutrient flux rates for the Missouri River inflow to Garrison Reservoir over the 5-year period of 2003 through 2007 were calculated based on water quality samples collected near Williston, North Dakota (i.e. site GARNFMORRR1) and the estimated flow conditions at the time of sample collection (Table 5.6). The maximum nutrient flux rates are attributed to greater nonpoint source nutrient loadings associated with runoff conditions.

Table 5.6. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River near Williston, ND (i.e., site GARNFMORRR1) during April through September over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	26	26	27	27	27	26
Mean	0.063	0.376	0.031	0.159	0.013	1.396
Median	0.045	0.187	n.d.	0.054	0.007	0.966
Minimum	n.d.	0.073	n.d.	0.010	n.d.	0.486
Maximum	0.324	1.407	0.298	0.861	0.068	4.572

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 16,685 cfs, median = 12,010 cfs, minimum = 7,649 cfs, and maximum = 38,300 cfs.

5.3.3.3 Continuous Water Temperature Monitoring of the Missouri River at the USGS Gaging Station near Williston, ND

Through an agreement with the USGS, a water temperature monitoring probe was added to the USGS's gage on the Missouri River near Williston, ND (i.e., site GARNFMORRR1). Beginning in 2005, water temperature measurements were recorded at the site. Plates 86 through 88, respectively, plot mean daily water temperature and river discharge determined for 2005, 2006, and 2007.

5.3.4 WATER QUALITY AT THE GARRISON POWERPLANT

5.3.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plates 89 and 90 summarize the water quality conditions that were monitored from water discharged through Garrison Dam during the 5-year period 2003 through 2007. Plate 89 summarizes the 1½-year period of June 2003 through 2004, and Plate 9 summarizes the 3-year period of 2005 through 2007. The 2003 and 2004 water quality data was separated from the 2005, 2006, and 2007 data because of the potential affects of implementing the short-term water quality management measures at Garrison Dam in the summer of 2005. A review of these results indicated no significant water quality concerns. Three dissolved oxygen measurements (<0.1%) did not meet the criterion of 5 mg/l during the 2003-2004 period (Plate 89). All three of the measurements occurred on October 1, 2004. No dissolved oxygen measurements recorded during the 2005-2007 period were below 5 mg/l (Plate 90). Over the 2003-2004 period, 9% of the water temperature measurements exceeded 15°C; while over the 2005-2007 period, 24% of the measurements exceeded 15°C (Plates 89 and 90). No recorded water temperatures exceeded 19°C in either period. These water temperatures are believed supportive of the cold and coolwater fishery that exists in the Garrison Dam tailwaters. The difference between the dissolved oxygen and water temperature measured during the two periods is attributed to the short-term water quality management measures that were implemented at Garrison Dam during the summer of 2005. Warmer water with higher dissolved oxygen concentrations was drawn from higher elevations in Garrison Reservoir due to the implemented short-term water quality management measures.

5.3.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time series plots for temperature and dam discharge monitored hourly at the Garrison powerplant during the 4½-year period of June 2003 through December 2007 were constructed (Plates 91 - 99). Monitored water temperatures showed seasonal cooling and warming through each calendar year. Daily water temperatures remained fairly stable during the winter, early spring, and late fall and exhibited considerable variability during the late spring, summer, and early fall. When thermal stratification becomes established in Garrison Reservoir during the late spring, the temperature of the water discharged through the dam becomes highly dependent upon the discharge rate of the dam. This indicates that the vertical extent of the withdrawal zone in the reservoir is dependent upon the discharge rate of the dam. This is believed to be a result of the design of the intake structure (i.e., bottom withdrawal) and the presence of the submerged intake channel leading to the intake structure. Water is likely drawn from an extended vertical zone in Garrison Reservoir year-round, but is only evident in the temperatures monitored at the powerhouse during reservoir thermal stratification during the summer. A decrease in the daily variability of the monitored temperatures in the summers of 2005, 2006, and 2007 occurred after the installation of plywood barriers on the lower portion of the trash racks in front of penstocks 2 and 3 in 2005 and penstock 1 in 2007. Plates 100 and 101 show plots of hourly water temperatures measured at the Garrison powerplant during the period of June through October for 2003, 2004, 2005, 2006, and 2007. It is evident that the installation of the plywood barriers in 2005 raised the temperature of the water passed through Garrison Dam and discharged to the Missouri River downstream during the summer. The increase in temperature was, on average, about 2°C.

Semiannual time series plots for dissolved oxygen and dam discharge monitored hourly at the Garrison powerplant during the 4½-year period of June 2003 through December 2007 were also constructed (Plates 102 - 110). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall. The lowest dissolved oxygen levels occurred during the late summer/early fall period. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The decreasing dissolved oxygen in the July to September period is attributed to ongoing degradation of dissolved oxygen in the lower hypolimnion in Garrison Reservoir as the summer progressed. Water is withdrawn from Garrison Reservoir into the dam's power tunnels approximately 2 feet above the reservoir bottom. During the late summer, dissolved oxygen levels were highly correlated to dam discharge rates in 2003 and 2004 and not as correlated in 2005, 2006, and 2007. This is attributed to the implementation of the short-term water quality management measures in 2005 through 2007.

Plates 111 and 112 show a plot of hourly dissolved oxygen concentrations measured at the Garrison powerplant during the period of June through October for 2003, 2004, 2005, 2006, and 2007. It is evident that the installation of the short-term water quality management measures in 2005 raised the dissolved oxygen concentrations of water passed through Garrison Dam and discharged to the Missouri River downstream during the summer. The plywood barriers allowed epilimnetic water, higher in dissolved oxygen, to be drawn into the power tunnel intakes and then to be discharged from the dam. Although the short-term water quality management measures were implemented to preserve coldwater habitat in Garrison Reservoir, they also had the probable benefit of preventing dissolved oxygen levels below the State of North Dakota's water quality standards criterion (i.e., 5 mg/l) from occurring in the Garrison Dam tailwaters during late summer low flow releases (Plate 112).

5.3.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Garrison Reservoir

Plates 113 through 115, respectively, plot the mean daily water temperatures monitored at the Missouri River near Williston, ND (site GARNFMORRR1) and the Garrison Dam powerplant (site GARPP1) for 2005, 2006, and 2007. Inflow temperatures of the Missouri River to Garrison Reservoir are generally warmer than the outflow temperatures of Garrison Dam during the period of April through September (Plates 113 - 115). Outflow temperatures of the Garrison Dam discharge are generally warmer than the inflow temperatures of the Missouri River during the period of October through March (Plates 113 - 115). A maximum temperature difference occurs in the summer when the Missouri River inflow temperature is about 10°C warmer than the Garrison Dam outflow temperature.

5.3.5 WATER QUALITY IN THE MISSOURI RIVER DOWNSTREAM OF GARRISON DAM

5.3.5.1 Water Temperatures Monitored at Garrison Dam and the USGS Gage Station at Bismarck, North Dakota in 2005 and 2006

Through an agreement with the USGS, a water temperature monitoring probe was added to the USGS's gage on the Missouri River at Bismarck, ND in 2005. The USGS gage at Bismarck, ND is located at RM1314.7 and is approximately 75 miles downstream of Garrison Dam. Plates 116 through 118, respectively, plot the mean daily flows and water temperatures monitored at the Garrison powerplant and USGS gage at Bismarck, ND in 2005, 2006, and 2007. Annually, the mean daily water temperature of the Missouri River at Bismarck is warmer than the Garrison Dam discharge from April through August and generally cooler from September through March (Plates 116 - 118). During the summers of 2005, 2006, and 2007, mean daily water temperatures at Bismarck were, respectively, up to 11°C, 6°C, and 8°C warmer than the Garrison Dam discharge (Plates 116 -118). The lower summer temperature differences in 2006 and 2007 are attributed to the full implementation of the short-term water quality management measures at Garrison Dam. Maximum summer mean daily water temperatures in the Missouri River at Bismarck were noticeably cooler (3°C) in 2006, compared to 2005 and 2007 (Plates 116 - 118).

5.3.5.2 Water Temperatures Monitored in the Reach from Garrison Dam to Bismarck, ND in 2005, 2006, and 2007

As part of their fisheries management program, the North Dakota Game and Fish Department (NDGFD) monitored water temperatures in the Missouri River from Garrison Dam (RM1389) to Beaver Bay (RM1259). Sites monitored in 2005 (June through September) included Stanton (RM1372), Burnt Creek (RM1322), Bismarck (RM1315), Fox Island (RM1312), and Beaver Bay (RM1259). Sites monitored in 2006 (May through September) included Stanton (RM1372), Washburn (RM1355), Wilton (RM1344), Burnt Creek, and North Beaver (RM1260). Sites monitored in 2007 (May through September) included Stanton (RM1372), Washburn (RM1355), Wilton (RM1344), and Bismarck (RM1315). Plates 119 through 121, respectively, plot mean daily water temperatures monitored in the Missouri River downstream from Garrison Dam in 2005, 2006, and 2007.

5.3.6 MANAGEMENT OF COLDWATER FISHERY HABITAT IN GARRISON RESERVOIR

5.3.6.1 Summer Occurrence of Optimal Coldwater Fishery Habitat in Garrison Reservoir

The occurrence of optimal coldwater fishery habitat in Garrison Reservoir was estimated from collected water temperature and dissolved oxygen depth-profile measurements and defined reservoir elevation and volume relationships. Plate 122 is a plot of the optimal coldwater fishery habitat estimated to have been present in Garrison Reservoir during summers of 2002 through 2007.

5.3.6.2 Implementation of Short-term Water Quality Management Measures to Preserve Optimal Coldwater Fishery Habitat in Garrison Reservoir

The potential impact of implementing the short-term water quality management measures on preserving the optimal coldwater fishery habitat in Garrison Reservoir during the summers of 2005, 2006, and 2007 was estimated by comparing the quantity of water meeting optimal coldwater conditions (i.e., ≤ 15°C and ≥ 5 mg/l dissolved oxygen) that was discharged through each of the dam's five penstocks. The water quality conditions monitored in penstocks 1, 2, and 3 were compared to penstocks 4 and 5. The water quality conditions monitored in penstocks 4 and 5 were taken to be the water quality conditions that would have occurred in penstocks 1, 2, and 3 if the plywood barriers were not in place. Installation of the plywood barriers on Units 2 and 3 was completed on July 22, 2005 and was completed on Unit 1 on May 19, 2007. During the summers of both 2005 and 2006, most of the water discharged through penstocks 4 and 5 prior to September 1 met optimal coldwater habitat conditions, while almost all the water discharged through penstocks 2 and 3 did not (i.e., water was warmer than 15°C). During the summer of 2007, most of the water discharged through penstocks 4 and 5 prior to September 1 met optimal coldwater habitat conditions, while almost all the water discharged through penstocks 1, 2, and 3 did not (i.e., water was warmer than 15°C). This resulted in a potential saving of optimal coldwater habitat in Garrison Reservoir of about 379,390 acre-ft in 2005, about 1,021,150 acre-ft in 2006, and about 827,928 acre-ft in 2007. All of the potential savings of optimal coldwater habitat occurred prior to early September. After early September, water temperatures in all the penstocks were above 15°C due to the downward expansion of the epilimnion in Garrison Reservoir.

5.4 OAHE

5.4.1 BACKGROUND INFORMATION

5.4.1.1 Project Overview

Oahe Dam is located on the Missouri River at RM 1072.3 in central South Dakota, 6 miles northwest of Pierre, SD. The closing of Oahe Dam in 1958 resulted in the formation of Oahe Reservoir (Lake Oahe). When full, the reservoir is 231 miles long, covers 374,000 acres, and has 2,250 miles of shoreline. Table 5.7 summarizes how the surface area, volume, mean depth, and retention time of Oahe Reservoir vary with pool elevations. Due to ongoing drought conditions, the reservoir, at the end of December 2007, was at pool elevation 1582.2 ft-msl. This is 25.3 feet below the top of the Carryover Multiple Use Zone (1607.5 ft-msl). Major inflows to the reservoir are the Missouri and Cheyenne Rivers. Water discharged through Oahe Dam for power production is withdrawn from Oahe Reservoir at elevation 1524 ft-msl, approximately 114 feet above the reservoir bottom.

Oahe Reservoir and Dam are authorized for the purposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. Over the period 1967 through 2007, the seven generating units at Oahe Dam have produced an annual average 2.677 million mega-watt hours (MWh) of electricity, which has a current revenue value of approximately $40 million. The ongoing drought in the interior western United States has curtailed releases and power production at the Missouri River mainstem system projects, including Oahe. Power production at the Oahe Dam generating units averaged an annual 1.508 MWh over the 5-year period 2003 through 2007. Habitat for one endangered species, interior least tern, and one threatened species, piping plover, occurs within the project area. Oahe Reservoir is used as a water supply by the town of Fort Yates, North Dakota, and the towns of Bear Creek, Blackfoot, Bridger, Cherry Creek, Dupree, Eagle Butte, Faith, Gettysburg, Green Grass, Iron Lightning, Lantry, LaPlante, Mobridge, Promise, Red Elm, Red Schaffold, Swiftbird, Thunder Butte, Wakpala, and White Horse, SD, as well as some individual cabins. The reservoir is an important recreational resource and a major visitor destination in South Dakota.

Table 5.7. Surface area, volume, mean depth, and retention time of Oahe Reservoir at different pool elevations.

Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
1620	374,135	23,136,960	61.8	1.33
1615	350,960	21,323,520	60.8	1.23
1610	325,765	19,630,460	60.3	1.13
1605	300,030	18,068,750	60.2	1.04
1600	281,010	16,618,390	59.1	0.96
1595	260,715	15,265,460	58.6	0.88
1590	245,190	14,002,600	57.1	0.81
1585	229,085	12,816,650	55.9	0.74
1580	213,150	11,711,030	54.9	0.67
1575	196,915	10,686,750	54.3	0.62
1570	182,933	9,737,896	53.2	0.56
1565	168,523	8,859,708	52.6	0.51
1560	155,510	8,049,792	51.8	0.46
1555	141,688	7,308,917	51.6	0.42
1550	133,628	6,622,830	49.6	0.38
1545	124,869	5,976,361	47.9	0.34
1540	116,560	5,373,030	46.1	0.31

Average Annual Inflow (1967 through 2007) = 18.10 Million Acre-Feet
Average Annual Outflow: (1967 through 2007) = 17.36 Million Acre-Feet
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 1620-1617 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 1617-1607.5 ft-msl), Carryover Multiple Use Zone (elev. 1607.5-1540 ft-msl), and Permanent Pool Zone (elev. 1540-1415 ft-msl). All elevations are in the NGVD 29 datum.

5.4.1.2 Water Quality Standards Classifications and Section 303(d) Listings

5.4.1.2.1 Oahe Reservoir

The State of South Dakota has designated the following water quality-dependent beneficial uses for Oahe Reservoir in the State's water quality standards: recreation (i.e., immersion and limited-contact), coldwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has not placed the reservoir on the State's Section 303(d) list of impaired waters and has not issued a fish consumption advisory for the reservoir.

5.4.1.2.2 Missouri River Downstream of Oahe Dam

The following beneficial uses have been designated by the State in their water quality standards for the Missouri River: recreation (i.e., immersion and limited-contact), coldwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has not placed the river on its Section 303(d) list of impaired waters and has not issued a fish consumption advisory for the river.

5.4.1.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Oahe Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the inflow to and outflow from the reservoir. A 3-year intensive water quality survey was completed at the Oahe Project in 2007, and the findings of the intensive survey are available in the separate report, "Water Quality Conditions Monitored at the Corps' Oahe Project in South Dakota during the 3-year period 2005 through 2007" (USACE, 2008b). Figure 5.5 shows the location of sites at the Oahe Project that have been monitored for water quality during the past 5 years (i.e., 2002 through 2006). The near-dam location (i.e., site OAHLK1073A) has been continuously monitored since 1980.

5.4.2 WATER QUALITY IN OAHE RESERVOIR

5.4.2.1 Existing Water Quality Conditions (2003 through 2007)

5.4.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Water quality conditions that were monitored in Oahe Reservoir at sites OAHLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, and OAHLK1196DW from May through September during the 5-year period 2003 through 2007 are summarized in Plates 123 through 129. A review of these results indicated possible water quality concerns regarding water temperature, dissolved oxygen, and pH for the support of coldwater permanent fish life propagation. Water temperatures in the epilimnion of the reservoir regularly exceed 18.3°C in the summer, while temperatures in the hypolimnion are less than 18.3°C. Dissolved oxygen levels in the hypolimnion continually degrade along the reservoir bottom as summer progresses and fall below 7.0 mg/l in late summer (i.e., occurred in non-spawning area outside the spawning season for coldwater species). Dissolved oxygen levels rarely fell below 6.0 mg/l in the hypolimnion in the area of the reservoir near Oahe Dam (Plate 123). Dissolved oxygen concentrations regularly fall below 6 mg/l in the middle and upstream reaches of the hypolimnion (Plates 125 - 127). As the summer progresses, conditions of lower dissolved oxygen move up from the reservoir bottom into the lower reaches of the hypolimnion. The lowest dissolved oxygen concentration measured at the seven sites was 2.7 mg/l, and occurred at site OAHLK1176DW on August 16, 2005. No measured pH values were below the lower pH criterion of 6.6. The upper pH criterion of 8.6 was exceeded throughout the reservoir; however, no measured pH values were above 9.

5.4.2.1.2 Summer Thermal Stratification

5.4.2.1.2.1 2007 Monthly Longitudinal Temperature Contour Plots

Summer thermal stratification of Oahe Reservoir during 2007 is described by the monthly longitudinal temperature contour plots based on depth-profile temperature measurements taken in June, July, August, and September (Plates 130 - 133). The contour plots were constructed along the length of the reservoir. As seen in Plates 130 through 133, water temperature in Oahe Reservoir varies longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom. The near-surface water in the upper reaches of the reservoir warms up sooner in the spring than the near-surface water near the dam (Plate 130). By mid-summer a strong thermocline becomes established in the lower reaches of the reservoir, and the near-surface waters of the entire reservoir above the thermocline are a fairly uniform temperature (Plates 131- 133). As the near-surface waters of the reservoir cool in the late summer, the thermocline is pushed deeper and these wind-mixed upper waters are fairly uniform in temperature (Plate 133). The vertical variation in temperature is most prevalent in the deeper area of the reservoir towards the dam where a strong thermocline becomes established during the summer. The shallower upper reaches of Oahe Reservoir do not exhibit much vertical variation of temperature during mid to late summer as wind action allows for complete mixing of the water column.

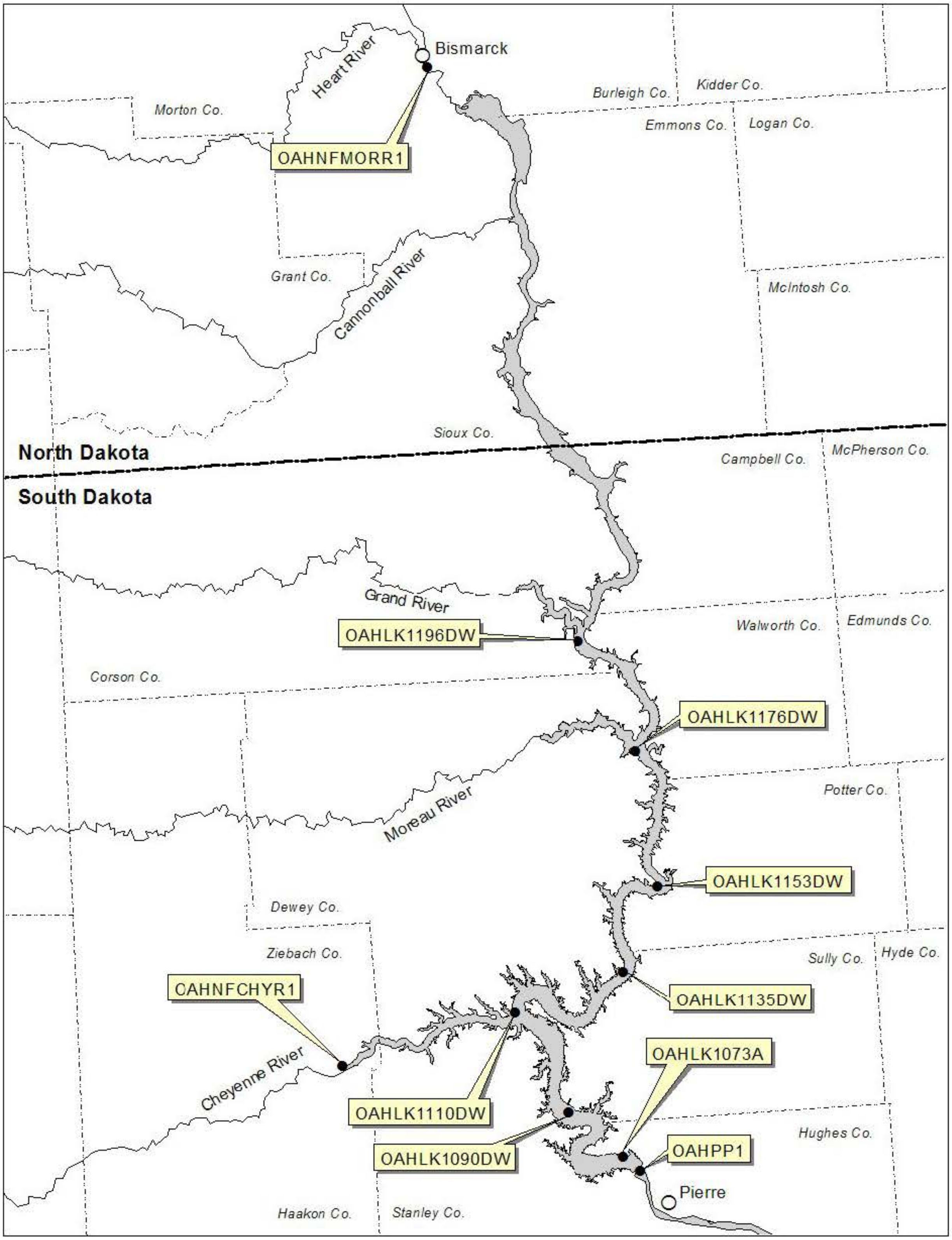

Figure 5.5. Location of sites where water quality monitoring was conducted by the District at the Oahe Project during the period 2003 through 2007.

5.4.2.1.2.2 Near-Dam Temperature Depth-Profile Plots

Existing summer thermal stratification of Oahe Reservoir at the deep water area near the dam is described by the depth-profile temperature plots measured over the 5-year period 2003 through 2007. Depth-profile temperature plots measured during the summer months were compiled (Plate 134). The plotted depth-profile measurements indicate that a significant temperature-depth gradient occurs in Oahe Reservoir in the near-dam lacustrine area during the summer, and a thermocline becomes established at a depth of about 20 meters (Plate 134).

5.4.2.1.3 Summer Dissolved Oxygen Conditions

5.4.2.1.3.1 2006 Monthly Longitudinal Dissolved Oxygen Contour Plots

Dissolved oxygen longitudinal contour plots were constructed along the length of Oahe Reservoir based on depth-profile measurements taken in June, July, August, and September of 2007 (Plates 135 - 138). During the summer of 2007, dissolved oxygen conditions in Oahe Reservoir varied longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom (Plates 135 - 138). Dissolved oxygen levels below 5 mg/l first appeared near the reservoir bottom in the upper-middle reaches of the reservoir in July (Plate 136). As the summer progressed, dissolved oxygen concentrations below 5 mg/l expanded along the bottom in the middle reaches of the reservoir (Plates 137 and 138). Near-bottom dissolved oxygen concentrations near the dam remained above 5 mg/l. The occurrence of low dissolved oxygen concentrations in the near-bottom water of the upper-middle reaches of Oahe Reservoir is attributed to the increased allochthonous organic loading in the transition zone of the reservoir and the lesser hypolimnetic volume available for assimilation of the oxygen demand. As this material decomposes, a "pool" of water with low dissolved oxygen levels accumulates near the bottom in this area of the reservoir. Decomposition of autochthonous organic matter also occurs in the lacustrine zone and results in dissolved oxygen degradation as the summer progresses, although at a slower rate than what occurs in the transition zone. The recovery of near-bottom dissolved oxygen concentrations to saturation levels takes longer in the lacustrine zone nearer the dam because of the time needed for thermal stratification to breakdown and mixing within the water column to occur in the deeper water.

5.4.2.1.3.2 Near-Dam Dissolved Oxygen Depth-Profile Plots

Existing summer dissolved oxygen conditions in Oahe Reservoir at the deep-water area near the dam are described by the depth-profile dissolved oxygen plots measured over the 5-year period 2003 through 2007. Depth-profile dissolved oxygen plots measured during the summer months at site OAHLK1073A were compiled (Plate 139). Dissolved oxygen levels exhibited a significant gradient with depth and tended toward a negative heterograde to orthograde vertical distribution (Plate 139). During the period of 2003 through 2007, dissolved oxygen concentrations in the lower hypolimnion did not fall below 6 mg/l. The lowest dissolved oxygen concentration measured at this site over the past 5 years was 6.0 mg/l, which was measured at the reservoir bottom on September 14, 2005.

5.4.2.1.4 Water Clarity

5.4.2.1.4.1 Secchi Transparency

Figure 5.6 displays a box plot of the Secchi depth transparencies measured at the seven in-reservoir monitoring sites during the period 2005 through 2007 (note: the seven monitoring sites are oriented in an upstream to downstream direction along the x-axis). Secchi depth transparency increased in a downstream direction from the upper reaches of the reservoir to near the dam (Figure 5.6). This is attributed to suspended sediment in the inflowing Missouri River settling out in the reservoir as current

velocities slow. The surface waters near Oahe Dam are significantly clearer than the upstream regions of the reservoir. Under the conditions that were monitored during the 2005 to 2007 period, it appears that site OAHLK1196DW was in the riverine zone; sites OAHLK1176DW and OAHLK1153DW were in the transition zone; sites OAHLK1135DW and OAHLK1110DW were in the boundary area between the transition and lacustrine zones; and sites OAHLK1090DW and OAHLK1073A were in the lacustrine zone of the reservoir.

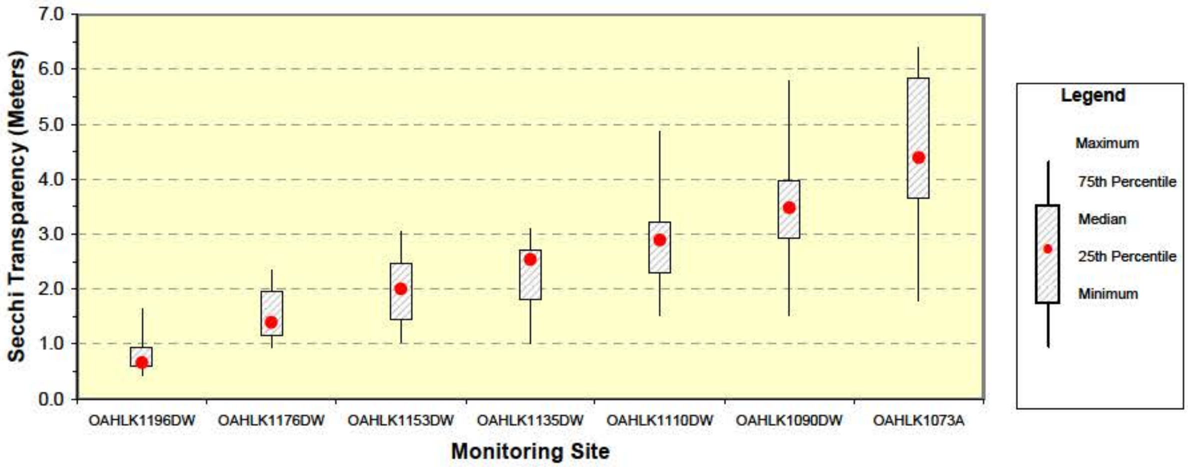

Figure 5.6. Box plot of Secchi transparencies measured in Oahe Reservoir during the period 2005 through 2006. (Note: monitoring sites are oriented on the x-axis in an upstream to downstream direction.)

5.4.2.1.4.2 Turbidity

Monthly (i.e., June, July, August, and September) longitudinal contour plots were prepared from the depth-profile turbidity measurements taken at sites OAHLK1073A, OAHLK1090DW, OAHLK1110DW, OAHRLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW, and OAHNFMORR1 during 2007 (Plates 140 - 143). As seen in Plates 140 through 143, turbidity levels in Oahe Reservoir vary longitudinally somewhat from the dam to reservoir's upper reaches and vertically somewhat from the reservoir surface to the bottom. Turbidity levels measured in the upper reaches Oahe Reservoir, although somewhat higher than the turbidity levels measured near the dam, are still of a low magnitude. It also appears that turbidity plumes may move through Oahe Reservoir as interflows; especially along the bottom (Plate 141). Given the low chlorophyll *a* concentrations monitored in Oahe Reservoir (Plates 123 - 129), turbidity in the reservoir is believed to be due to suspended inorganic material largely attributed to the inflowing Missouri River.

5.4.2.1.5 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Oahe Reservoir during the summer at the near-dam, deepwater area (i.e., site OAHLK1073A) over the 5-year period 2003 through 2007 were compared. Near-surface samples were taken to be samples collected within 2 meters of the reservoir surface, and near-bottom samples were taken to be samples collected within 2 meters of the reservoir bottom. Box plots were used to display the distribution of paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 144). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the

measurements. The only parameter that significantly varied between the surface and bottom was water temperature (Plate 144).

5.4.2.1.6 Reservoir Trophic Status

Trophic State Index (TSI) values for Oahe Reservoir were calculated from monitoring data collected during the past 3 years (Table 5.8). The calculated TSI values indicate that the lacustrine zone of the reservoir (i.e., sites OAHLK1073A and OAHLK1110DW) is mesotrophic, the transition zone (i.e., site OAHLK1153DW) is moderately eutrophic, and the riverine zone (i.e., site OAHLK11961DW) is eutrophic. However, it is noted that the calculated average TSI value for the riverine zone is greatly influenced by the low water clarity in this part of the reservoir. This lack of water clarity is largely attributed to suspended inorganic material delivered to the reservoir by the Missouri River. Thus, the higher TSI values in the riverine zone seemingly are not indicative of increased algal growth associated with nutrient enrichment.

Table 5.8. Mean Trophic State Index (TSI) values calculated for Oahe Reservoir. TSI values are based on monitoring at the identified four sites during period 2005 through 2007.

Monitoring Site	Mean – TSI (Secchi Depth)	Mean – TSI (Total Phos.)	Mean – TSI (Chlorophyll)	Mean – TSI (Average)
OAHLK1073A	41	51	44	46
OAHLK1110DW	45	54	43	47
OAHLK1153DW	51	56	50	52
OAHLK1196DW	64	55	54	58

Note: See Section 4.1.4 for discussion of TSI calculation.

5.4.2.1.7 Phytoplankton Community

Phytoplankton grab samples collected from Oahe Reservoir at sites OAHLK10730A, OAHLK1110DW, OAHLK1153DW, and OAHLK1196DW during the spring and summer of the 5-year period 2003 through 2007 are summarized in Plates 145 through 148. The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta/Cyanobacteria > Cryptophyta > Pyrrophyta > Chrysophyta > Euglenophyta. The diatoms were generally the most abundant algae based on percent composition (Plates 145 - 148). The Shannon-Weaver genera diversity indices calculated for the 54 phytoplankton samples collected at the four sites ranged from 0.55 to 2.53 and averaged 1.60 at site OAHLK1073A, 1.73 at site OAHLK1110DW, 1.46 at site OAHLK1153DW, and 1.50 at site OAHLK1196DW. Dominant phytoplankton species occurring in the 19 samples collected at site OAHLK1073A included the Bacillariophyta *Fragilaria spp.* (11 occasions), *Asterionella spp.* (7 occasions), *Stephanodiscus spp.* (3 occasions), *Aulacoseira spp.* (2 occasions), , *Cyclotella spp.* (2 occasion), *Navicula spp.* (1 occasion), *Synedra spp.* (1 occasion), and *Tabellaria* (1 occasion); Chlorophyta *Costmaries spp.* (3 occasions), *Chlamydomonas spp.* (1 occasion), and *Golenkinia spp.* (1 occasion); Chrysophyta *Dinobryon spp.* (4 occasions); Cryptophyta *Rhodomonas spp.* (7 occasions) and *Cryptomonas spp.* (2 occasions); Cyanobacteria *Anabaena spp.* (4 occasions); and Pyrrophyta *Ceratium spp.* (7 occasions) and *Peridinium spp.* (2 occasions) (Plate 149). No concentrations of microcystins above 1 ug/l were monitored in Garrison Reservoir during 2005 through 2007.

5.4.2.2 Water Quality Trends (1980 through 2007)

Water quality trends over the 28-year period of 1980 through 2007 were determined for Oahe Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through September at the near-dam, ambient monitoring site (i.e., site OAHLK1073A). Plate 150 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. It appears that the reservoir exhibited slightly increasing concentrations of total phosphorus. There was no observed trend in transparency (i.e. Secchi depth) and chlorophyll *a*. Over the 28-year period, Oahe Reservoir has generally remained in a mesotrophic state with calculated TSI values showing no observable trend (Plate 150).

5.4.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI RIVER INFLOW TO OAHE RESERVOIR

5.4.3.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

The water quality conditions that were monitored in the Missouri River at Bismarck, ND (i.e., site OAFNFMORR1) monthly from May through September and annually during the 3-year period 2005 through 2007 are summarized in Plates 151 and 152. A review of these results indicated no major water quality concerns.

5.4.3.2 Missouri River Inflow Nutrient Flux Conditions

Nutrient flux rates for the Missouri River inflow to Oahe Reservoir during the 3-year period 2005 through 2007 were calculated based on water quality samples collected near Bismarck, ND (i.e. site OAHNFMORR1) and the estimated flow conditions at the time of sample collection (Table 5.9). The maximum nutrient flux rates are attributed to greater nonpoint-source nutrient loadings associated with runoff conditions.

Table 5.9. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Bismarck, ND during May through September over the 3-year period 2005 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	15	15	14	15	15	14
Mean*	15	0.128	0.033	0.051	-----	1.411
Median	0.010	0.135	0.033	0.025	0.009	1.513
Minimum	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum	0.049	0.153	0.063	0.103	0.016	2.277

n.d. = non-detectable.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported

Note: Statistics of Missouri River flows used for flux calculations were: mean = 17,053 cfs, median = 16,000 cfs, minimum = 11,899 cfs, and maximum = 26,800 cfs.

5.4.3.3 Continuous Water Temperature Monitoring of the Missouri River at the USGS Gaging Station at Bismarck, North Dakota

Through an agreement with the USGS, a water temperature monitoring probe was added to the USGS's gage on the Missouri River near Bismarck, ND (i.e., site OAHNFMORR1). Beginning in 2005, water temperature measurements were recorded at the site. Plates 153, 154, and 155 respectively, plot mean daily water temperature and river discharge determined for 2005, 2006, and 2007.

5.4.4 WATER QUALITY AT THE OAHE POWERPLANT

5.4.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 156 summarizes the water quality conditions that were monitored from water discharged through Oahe Dam during 4-year period 2004 through 2007. A review of these results indicated possible water quality concerns regarding temperature for the support of coldwater permanent fish life propagation.

Twenty-nine percent of the "grab sample" water temperature measurements taken on the water passed through Oahe Dam exceeded the State water quality temperature criterion of 18.3°C. The exceedences of the 18.3°C temperature criterion occurred during the summer. During the summer when Oahe Reservoir is thermally stratified, water temperatures in the epilimnion of the reservoir regularly exceed 18.3°C, while temperatures in the hypolimnion are less than 18.3°C. Water discharged through Oahe Dam for power production is withdrawn from Oahe Reservoir at elevation 1524 ft-msl, approximately 114 feet above the reservoir bottom. Thus, water withdrawn from the reservoir in the summer comes largely from the epilimnion, especially when pool elevations are lower due to drought conditions (see Plates 131 and 132). Because water passed through Oahe Dam during the summer is withdrawn from the epilimnion of the reservoir, the temperature criterion of 18.3°C for the Missouri River and Big Bend Reservoir just downstream of the dam are not being met during the summer when Oahe Reservoir is thermally stratified.

5.4.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time-series plots for temperature, dissolved oxygen, and dam discharge monitored at the Oahe powerplant during the 4-year period January 2004 through December 2007 were constructed. Water temperatures showed seasonal warming and cooling through each calendar year (Plates 157 - 164). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall (Plates 165 - 172). The lowest dissolved oxygen levels occurred during the late summer period. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The decreasing dissolved oxygen in the July to September period may also be attributed somewhat to the influence of ongoing degradation of dissolved oxygen in the hypolimnion as the summer progressed. There appeared to be little correlation between discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 157 - 172).

5.4.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Oahe Reservoir

Plates 173, 174, and 175, respectively, plot the mean daily water temperatures monitored at the Missouri River near Bismarck, ND (site OAHNFMORR1) and the Oahe Dam powerplant (site OAHPP1) for 2005, 2006, and 2007. Inflow temperatures of the Missouri River to Oahe Reservoir are generally

warmer than the outflow temperatures of Oahe Dam during the period of April through June (Plates 173 - 175). Outflow temperatures of the Oahe Dam discharge are generally warmer than the inflow temperatures of the Missouri River during the period of July through March (Plates 173 - 175). A maximum temperature difference occurs in the fall when the Oahe Dam outflow temperature is about 4°C warmer than the Missouri River inflow temperature.

5.5 BIG BEND

5.5.1 BACKGROUND INFORMATION

5.5.1.1 Project Overview

Big Bend Dam is located in central South Dakota on the Missouri River at RM 987.4, 21 miles northwest of Chamberlain, SD. The closing of Big Bend Dam in 1963 resulted in the formation of Big Bend Reservoir (Lake Sharpe). The reservoir, when full, is 80 miles long, covers 61,000 acres, and has 200 miles of shoreline. Table 5.10 summarizes how the surface area, volume, mean depth, and retention time of Big Bend Reservoir vary with pool elevations. The Big Bend powerplant is operated to meet peak power demands for electricity. Generally, weekly flows from Oahe Dam are released at Big Bend Dam, and there is minimal fluctuation in the water level of Big Bend Reservoir. The Annual Flood Control and Multiple Use Zone in the reservoir does not provide for seasonal regulation of flood inflows like the other major upstream Mainstem System projects, but the zone is used for day-to-day and week-to-week power operations. The Corps normally strives to maintain the pool level in the reservoir between elevation 1419 ft-msl and 1421.5 ft-msl. There are no minimum flow requirements below Big Bend Dam, and hourly releases can fluctuate from 0 to 110,000 cfs for peaking power generation. The major inflows to Big Bend Reservoir are the Missouri River and Bad River. Water discharged through Big Bend Dam for power production is withdrawn from the surface of Big Bend Reservoir.

The reservoir and dam are authorized for the purposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. The powerplant has eight generating units that produce an annual average 0.989 million megawatt hours of electricity, valued in excess of $16 million in revenue. The ongoing drought in the interior western United States has curtailed releases and power production at the Missouri River mainstem system projects, including Big Bend. Power production at the Big Bend Dam generating units averaged an annual 0.660 MWh over the 5-year period 2003 through 2007. Habitat for one endangered species, interior least tern, and one threatened species, piping plover, occurs within the project area. Big Bend Reservoir is used as a water supply by the cities of Pierre, Fort Pierre, Fort Thompson, and Lower Brule, South Dakota. The reservoir is an important recreational resource.

5.5.1.2 Water Quality Standards Classification and Section 303(d) Listings

5.5.1.2.1 Big Bend Reservoir

Pursuant to the Federal CWA, the State of South Dakota has designated the following water quality-dependent beneficial uses for Big Bend Reservoir: recreation (i.e., immersion and limited-contact), coldwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has recently removed Big Bend Reservoir from the State's Section 303(d) list of impaired waters. The reservoir was previously listed as impaired due to accumulated sediment from the Bad River watershed. A total maximum daily load (TMDL) was developed and is being implemented to address this concern, resulting in the delisting of Big Bend Reservoir. South Dakota has not issued a fish consumption advisory for the reservoir.

Table 5.10. Surface area, volume, mean depth, and retention time of Big Bend Reservoir at different pool elevations.

Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
1430	70,615	2,259,568	32.0	0.1316
1425	63,808	1,923,508	30.1	0.1121
1420	57,007	1,621,484	28.4	0.0945
1415	50,224	1,353,339	26.9	0.0788
1410	43,146	1,119,548	25.9	0.0652
1405	35,694	923,872	25.9	0.0538
1400	31,842	756,297	23.8	0.0441
1395	27,402	608,587	22.2	0.0355
1390	24,659	479,172	19.4	0.0279
1385	21,779	362,729	16.7	0.0211
1380	18,307	262,285	14.3	0.0153
1375	14,856	179,548	12.1	0.0105
1370	11,747	113,160	9.6	0.0066
1365	8,590	62,333	7.3	0.0036
1360	5,449	27,069	5.0	0.0016
1355	2,021	9,373	4.6	0.0005
1350	836	2,445	2.9	0.0001

Average Annual Inflow (1967 through 2007) = 17.34 Million Acre-Feet.
Average Annual Outflow: (1967 through 2007) = 17.16 Million Acre-Feet.
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 1423-1422 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 1422-1420 ft-msl), Carryover Multiple Use Zone (none), and Permanent Pool Zone (elev. 1420-1345 ft-msl). All elevations are in the NGVD 29 datum.

5.5.1.2.2 Missouri River Downstream of Big Bend Dam

The State of South Dakota has designated the following water quality-dependent beneficial uses for the Missouri River downstream of Big Bend Dam: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. Big Bend Dam is the demarcation point between coldwater and warmwater use designation on the Missouri River system in South Dakota. Therefore, the designated use of warmwater permanent fish life propagation applies to the Big Bend Dam tailwaters instead of the coldwater permanent fish life propagation use that applies to Big Bend Reservoir. South Dakota has not issued a fish consumption advisory for the Missouri River downstream of Big Bend Dam.

5.5.1.2.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Big Bend Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the inflow to and outflow from the reservoir. The water quality conditions of the Oahe Dam discharge are taken to represent the inflow water quality conditions to Big Bend Reservoir. Figure 5.7 shows the location of sites at the Big Bend Project that have been monitored for water quality during the past 5 years (i.e., 2002 through 2006). The near-dam location (i.e., site BBDLK0987A) has been continuously monitored since 1980.

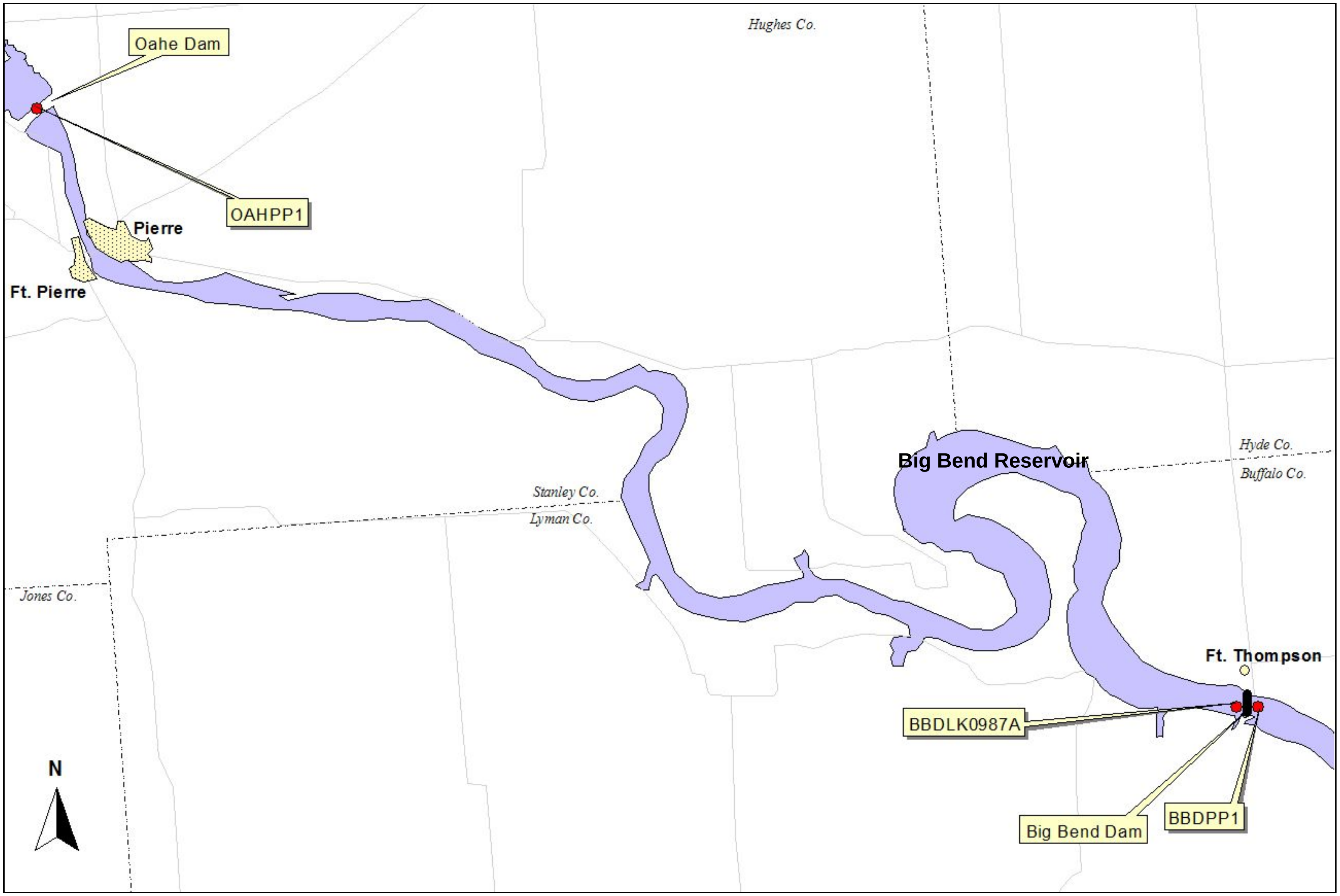

Figure 5.7. Location of sites where water quality monitoring was conducted by the District at the Big Bend Project during the period 2003 through 2007.

5.5.2 WATER QUALITY IN BIG BEND RESERVOIR

5.5.2.1 Existing Water Quality Conditions (2003 through 2007)

5.5.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 176 summarizes the water quality conditions that were monitored in Big Bend Reservoir from May through September during the 5-year period 2003 through 2007. A review of these results indicated possible water quality concerns regarding water temperature, dissolved oxygen and pH for the support of coldwater permanent fish life propagation. Based on the criteria for the protection of coldwater permanent fish life propagation, 66% of the observations exceeded water temperature criteria, 4 to 19% of the observations did not meet dissolved oxygen criteria, and 27% of the observations exceeded the pH criteria. It is noted that if Big Bend Reservoir were classified for the protection of warmwater permanent fish propagation instead of coldwater, no observations would have exceeded the pH criteria, and less than 1% of the observations would not have met the water temperature and dissolved oxygen criteria for warmwater permanent fish propagation. Ambient summer water temperatures in Big Bend Reservoir do not appear to be cold enough to support coldwater permanent fish life propagation as defined by State water quality criteria. Consideration should be given to reclassify the reservoir for a warmwater permanent fish life propagation use based on a use attainability assessment of "natural conditions" regarding ambient water temperatures.

5.5.2.1.2 Summer Thermal Stratification

Existing summer thermal stratification was assessed for Big Bend Reservoir, based on monitoring results obtained at the near-dam, deepwater ambient monitoring site during the past 5 years (i.e., 2003 through 2007). Temperature depth profiles were constructed from water quality data collected during the summer months (Plate 177). No significant temperature-depth gradient was indicated in Big Bend Reservoir in the near-dam lacustrine area during the summer (Plate 177).

5.5.2.1.3 Summer Dissolved Oxygen Conditions

Existing summer dissolved oxygen conditions were assessed for Big Bend Reservoir, based on monitoring results obtained at the near-dam, deepwater ambient monitoring site. Dissolved oxygen depth profiles were constructed from water quality data collected during the summer months during the 5-year period of 2003 through 2005 (Plate 178). Except for one occasion, dissolved oxygen levels measured in the near-dam lacustrine area of the reservoir did not exhibit a large gradient with depth and tended toward an orthograde vertical distribution (Plate 178). On one occasion (July 13, 2005), dissolved oxygen levels below 5 mg/l were measured within 5 meters of the reservoir bottom.

5.5.2.1.4 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Big Bend Reservoir at the near-dam, deepwater area (i.e., site BBDLK0987A) during the summer over the 5-year period 2003 through 2007 were compared. Near-surface samples were taken to be samples collected within 2 meters of the reservoir surface, and near bottom-samples were taken to be samples collected within 2 meters of the reservoir bottom. Box plots were used to display the distribution of paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 179). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. No parameter significantly varied between the surface and bottom (Plate 179).

5.5.2.1.5 Reservoir Trophic Status

Trophic State Index (TSI) values for Big Bend Reservoir were calculated from monitoring data collected at the near-dam, ambient monitoring site (i.e., site BBDLK0987A) during the 5-year period 2003 through 2007. Table 5.11 summarizes the TSI values calculated for the reservoir. The TSI values indicate that the near-dam lacustrine area of Big Bend Reservoir is in a mesotrophic state.

Table 5.11. Summary of Trophic State Index (TSI) values calculated for Big Bend Reservoir for the 5-year period 2003 through 2007.

TSI	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	28	51	51	37	60
TSI(TP)	29	49	48	41	70
TSI(Chl)	23	45	46	40	59
TSI(Avg)	30	49	50	40	56

Note: See Section 4.1.4 for discussion of TSI calculation.

5.5.2.1.6 Phytoplankton Community

Phytoplankton grab samples collected from Big Bend Reservoir at site BBDLK0987A during the spring and summer of the 4-year period 2004 through 2007 are summarized in Plate 180. The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta/Cyanobacteria > Cryptophyta/Pyrrophyta > Chrysophyta > Euglenophyta. The diatoms were generally the most abundant algae based on percent composition (Plate 180). The Shannon-Weaver genera diversity indices calculated for the 18 phytoplankton samples collected at site BBDLK0987A averaged 1.57. Dominant phytoplankton species occurring in the 18 samples collected at site BBDLK0987A included the Bacillariophyta *Fragilaria spp.* (8 occasions), *Asterionella spp.* (5 occasions), *Stephanodiscus spp.* (3 occasions), *Cyclotella spp.* (1 occasion), *Navicula spp.* (1 occasion), and *Tabellaria spp.* (1 occasion); Chlorophyta *Cosmarium spp.* (1 occasion) and *Pediastrum spp.* (1 occasion); Chrysophyta *Dinobryon spp.* (2 occasions); Cryptophyta *Rhodomonas spp.* (5 occasions) and *Cryptomonas spp.* (1 occasion); Cyanobacteria *Anabaena spp.* (2 occasion), *Dactylococcopsis spp.* (1 occasion), *Gomphosphaeria spp.* (1 occasion), and *Pseudanabaena spp.* (1 occasion); and Pyrrophyta *Ceratium spp.* (3 occasions) (Plate 181). No detectable concentrations of the Cyanobacteria microcystins toxin were monitored at site BBDLK0987A during 2005 through 2007 (Plate 176).

5.5.2.2 <u>Water Quality Trends (1980 through 2007)</u>

Water quality trends over the 28-year period of 1980 through 2007 were determined for Big Bend Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through October at the near-dam, ambient monitoring site (i.e., site BBDLK0987A). Plate 182 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. It appears that the reservoir exhibited increasing concentrations of total phosphorus and decreasing levels of chlorophyll

a and transparency (i.e. Secchi depth). Over the 28-year period, Big Bend Reservoir has generally remained in a mesotrophic to moderately eutrophic state with calculated TSI values showing no observable trend (Plate 182).

5.5.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI RIVER INFLOW TO BIG BEND RESERVOIR

5.5.3.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

The water quality conditions of the Missouri River inflow to Big Bend Reservoir is taken to be the monitored water quality conditions of the outflow from Oahe Dam. See Plate 156 for a summary of the water quality conditions monitored on the water discharged through Oahe Dam.

5.5.3.2 Missouri River Inflow Nutrient Flux Conditions

Nutrient flux rates for the Missouri River inflow to Big Bend Reservoir over the last 4 years were calculated based on water quality conditions monitored on water discharged through Oahe Dam (i.e. site OAHPP1) (Table 5.12). The maximum nutrient flux rates are attributed to higher flows during maximum power production at Oahe Dam.

Table 5.12. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Oahe Dam (i.e., site OAHPP1) over the 4-year period 2004 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	38	38	38	38	23	36
Mean*	-----	0.231	-----	-----	-----	1.702
Median	0.013	0.216	n.d.	0.012	n.d.	1.498
Minimum	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum	0.347	0.775	0.059	0.245	0.0.31	4.086

n.d. = non-detectable.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported

Note: Statistics of Missouri River flows used for flux calculations were: mean = 20,365cfs, median = 18,900 cfs, minimum = 0 cfs, and maximum = 48,097 cfs.

5.5.3.3 Mean Daily Discharge and Temperature

Mean daily discharge and water temperature of the Oahe Dam outflow was determined for 2005 through 2007. These are considered the water quality conditions of the Missouri River inflow to Big Bend Reservoir. Plates 183, 184, and 185, respectively, plot 2005, 2006, and 2007 mean daily water temperature and flow for the Oahe Dam discharge.

5.5.4 WATER QUALITY AT THE BIG BEND DAM POWERPLANT

5.5.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 186 summarizes the water quality conditions that were monitored on water discharged through Big Bend Dam during the 4-year period 2004 through 2007. A review of these results found no significant water quality concerns. On a one occasion, the measured dissolved oxygen concentration was 3.8 mg/l, which is below the water quality standards dissolved oxygen criterion of 5 mg/l for the protection of warmwater permanent fish life propagation.

5.5.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time-series plots for temperature, dissolved oxygen, and dam discharge monitored at the Big Bend powerplant during the 4-year period January 2004 through December 2007 were constructed. Water temperatures showed seasonal warming and cooling through each calendar year (Plates 187 - 194). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall (Plates 195 - 202). The lowest dissolved oxygen levels occurred during the late summer period. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. There appeared to be some correlation between discharge rates and water temperature and dissolved oxygen concentrations measured during the summer months (Plates 187 - 202). The lower dissolved oxygen concentrations monitored in the summer may represent dissolved oxygen degradation in the "raw water" supply line in the powerplant, especially during periods when the water may be static (i.e., no flow through the powerplant).

5.5.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Big Bend Reservoir

Plates 203 through 205, respectively, plot the mean daily water temperatures monitored for the Missouri River at Oahe Dam (site OAHPP1) and the Big Bend Dam powerplant (site BBDPP1) for 2005, 2006, and 2007. Inflow temperatures of the Missouri River to Big Bend Reservoir are about 2°C warmer than the outflow temperatures of Big Bend Dam during the winter (Plates 203 - 205). Outflow temperatures of the Big Bend Dam discharge are about 1-2°C warmer than the inflow temperatures of the Missouri River during the spring, summer, and fall (Plates 203-205).

5.6 FORT RANDALL

5.6.1 BACKGROUND INFORMATION

5.6.1.1 Project Overview

Fort Randall Dam is located on the Missouri River at RM 880.0 in southeastern South Dakota, 50 miles southwest of Mitchell, SD. The closing of Fort Randall Dam in 1952 resulted in the formation of Fort Randall Reservoir (Lake Francis Case). When full, the reservoir is 107 miles long, covers 102,000 acres, and has 540 miles of shoreline. Table 5.13 summarizes how the surface area, volume, mean depth, and retention time of Fort Randall Reservoir vary with pool elevations. The reservoir at the end of December 2007 was at pool elevation 1343.0 ft-msl. This is 7 feet below the top of the Carryover Multiple Use Zone (1350.0 ft-msl). A "low" pool level is typical for Fort Randall Reservoir at the end of December because this reservoir is drawn down each fall to provide storage space for high winter power releases from Oahe and Big Bend. Major inflows to Fort Randall Reservoir are the Missouri River and White River. Water discharged through Fort Randall Dam for power production is withdrawn from Fort Randall Reservoir at elevation 1229 ft-msl, approximately 2 feet above the reservoir bottom.

Table 5.13. Surface area, volume, mean depth, and retention time of Fort Randall Reservoir at different pool elevations.

Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
1370	98,438	4,916,698	49.9	0.270
1365	94,801	4,433,011	46.7	0.244
1360	89,808	3,971,266	44.2	0.218
1355	85,453	3,531,526	41.3	0.194
1350	76,747	3,124,368	40.7	0.172
1345	68,588	2,761,139	40.3	0.152
1340	59,783	2,439,591	40.8	0.134
1335	50,547	2,165,606	42.8	0.119
1330	45,845	1,926,136	42.0	0.106
1325	40,277	1,711,773	42.5	0.094
1320	37,911	1,517,486	40.0	0.083
1315	35,000	1,335,568	38.2	0.073
1310	33,632	1,164,645	34.6	0.064
1305	32,119	1,000,024	31.1	0.055
1300	30,297	843,949	27.9	0.046
1295	28,608	696,350	24.3	0.038
1290	26,042	559,475	21.5	0.031

Average Annual Inflow (1967 through 2007) = 18.23 Million Acre-Feet.
Average Annual Outflow: (1967 through 2007) = 17.96 Million Acre-Feet.
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 1375-1365 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 1365-1350 ft-msl), Carryover Multiple Use Zone (1350-1320 ft-msl), and Permanent Pool Zone (elev. 1320-1227 ft-msl). All elevations are in the NGVD 29 datum.

Fort Randall was authorized for the purposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. The powerplant has eight generating units that produce an annual average 1.757 million megawatt hours of electricity, valued in excess of $28 million in revenue. Habitat for two endangered species, pallid sturgeon and interior least tern, and one threatened species, piping plover, occur within the project area. Fort Randall Reservoir is used as a water supply by the communities of Chamberlain, Dante, Geddes, Greenwood, Kimball, Lake Andes, Marty, Oacoma, Platte, Pickstown, Pukkwana, Ravinia, Reliance, Wagner, and White Lake, SD. The reservoir is an important recreational resource and a major visitor destination in South Dakota.

5.6.1.2 <u>Water Quality Standards Classification and Section 303(d) Listings</u>

5.6.1.2.1 Fort Randall Reservoir

The State of South Dakota has designated the following water quality-dependent beneficial uses for Fort Randall Reservoir in the State's water quality standards: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has not placed Fort Randall Reservoir on the State's Section 303(d) list of impaired waters and has not issued a fish consumption advisory for the reservoir.

5.6.1.2.2 Missouri River Downstream of Fort Randall Dam

South Dakota's water quality standards designate the following beneficial uses for the Missouri River downstream of Fort Randall Dam: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of South Dakota has not placed the Missouri River downstream of Fort Randall Dam on the State's Section 303(d) list of impaired waters and has not issued a fish consumption advisory for the river.

5.6.1.2.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Fort Randall Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the inflow to and outflow from the reservoir. The water quality conditions of the Big Bend Dam discharge are taken to represent the inflow water quality conditions to Fort Randall Reservoir. A 3-year intensive water quality survey was initiated at the Fort Randall Project in 2006. Figure 5.8 shows the location of sites at the Fort Randall Project that have been monitored for water quality during the past 5 years (i.e., 2003 through 2007). The near-dam location (i.e., site FTRLK0880A) has been continuously monitored since 1980.

5.6.2 WATER QUALITY IN FORT RANDALL RESERVOIR

5.6.2.1 Existing Water Quality Conditions (2003 through 2007)

5.6.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Water quality conditions that were monitored in Fort Randall Reservoir at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, and FTRLK0968DW from May through September during the 5-year period 2003 through 2007 are summarized in Plates 206 through 212. A review of these results indicated possible water quality concerns regarding dissolved oxygen, pH, and suspended solids for the support of warmwater permanent fish life propagation. Dissolved oxygen levels in the hypolimnion degrade along the reservoir bottom as summer progresses and fall below 5.0 mg/l in July and August (Plates 206 - 209). The lowest dissolved oxygen concentration measured at the seven sites was 1.5 mg/l and occurred at site FTRLK0880A on August 16, 2007. The pH criterion of 9.0 SU was exceeded at all seven sites, with the highest pH value measured being 9.3 SU (Plates 206 - 208). The chronic suspended solids criterion was exceeded in Fort Randall Reservoir in the area near the confluence of the White River (Plate 210).

5.6.2.1.2 Summer Thermal Stratification

5.6.2.1.2.1 2006 Monthly Longitudinal Temperature Contour Plots

Summer thermal stratification of Fort Randall Reservoir during 2007 is described by the monthly longitudinal temperature contour plots based on depth-profile temperature measurements taken in June, July, August, and September (Plates 213 - 216). The contour plots were constructed along the length of the reservoir. As seen in Plates 213 through 216, water temperature in Fort Randall Reservoir varies longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom. Water temperatures in the upper reaches of the reservoir are influenced by the discharges from Big Bend Dam (RM987) and inflows from the White River (RM956). It appears that inflows from the White River tend to locally warm Fort Randall Reservoir in the spring and early-summer (Plates 213 - 215) and locally cool the reservoir in late-summer/early-fall (Plate 216). In late-spring and early-summer an appreciable vertical thermal gradient was present in the lacustrine downstream region of the reservoir (Plates 213 and 214). By late summer this vertical thermal gradient had diminished greatly (Plate 215).

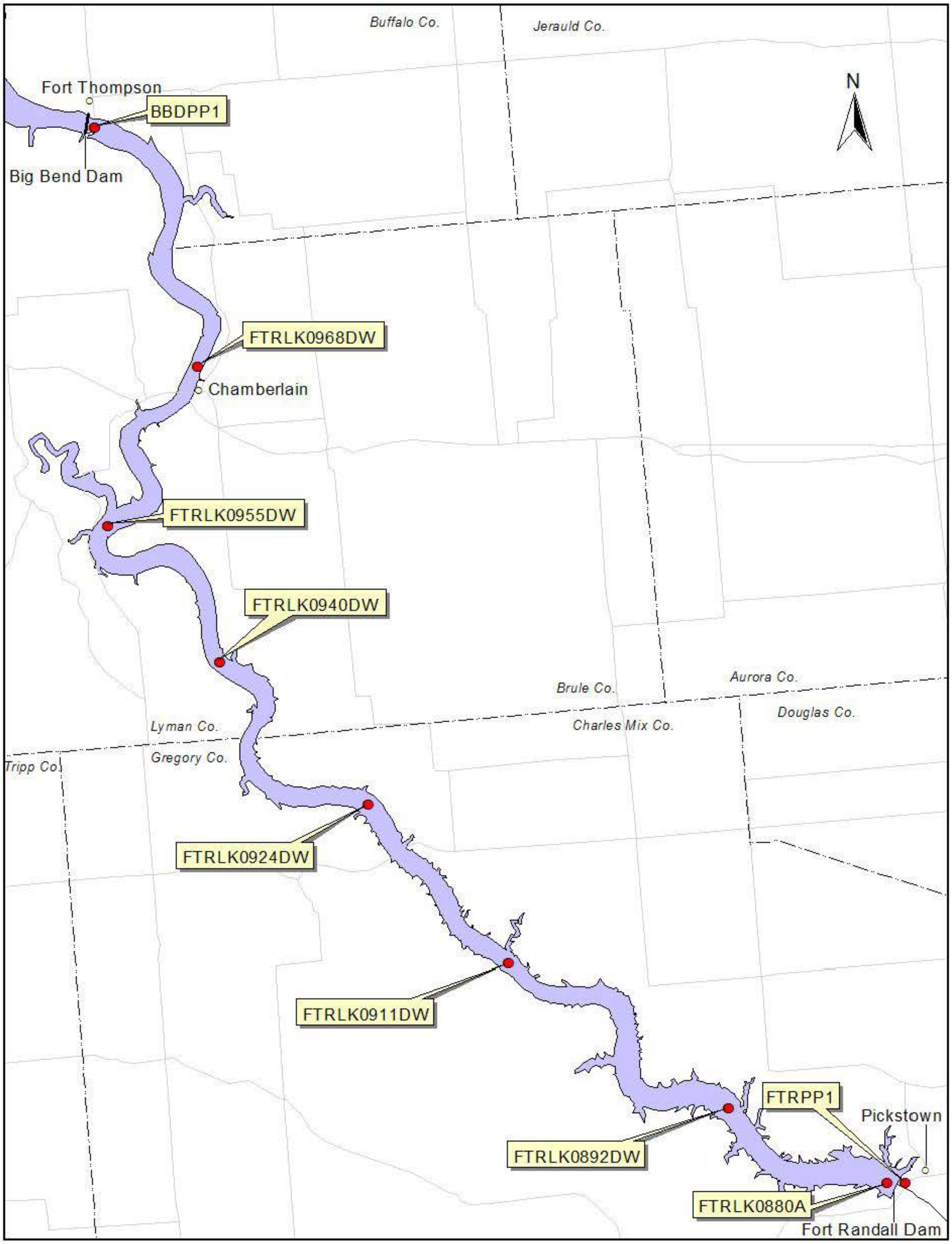

Figure 5.8. Location of sites where water quality monitoring was conducted by the District at the Fort Randall Project during the period 2003 through 2007.

5.6.2.1.2.2 Near-Dam Temperature Depth-Profile Plots

Existing summer thermal stratification of Fort Randall Reservoir at the deep water area near the dam is described by the depth-profile temperature plots measured over the 5-year period 2003 through 2007. Depth-profile temperature plots measured during the summer months at site FTRLK0880A were compiled (Plate 217). The plotted depth-profile measurements indicate that a moderate temperature-depth gradient occasionally occurs in Fort Randall Reservoir in the near-dam lacustrine area during the summer. A significant thermocline develops in the late spring/early summer, but appears to break down in late August (Plates 213 - 215). When a thermocline was established it occurred at a depth of about 25 meters (Plate 217).

5.6.2.1.3 Summer Dissolved Oxygen Conditions

5.6.2.1.3.1 2007 Monthly Longitudinal Dissolved Oxygen Contour Plots

Dissolved oxygen contour plots were constructed along the length of Fort Randall Reservoir based on depth-profile measurements taken in June, July, August, and September of 2007 (Plates 218 - 221). During the summer of 2007, dissolved oxygen conditions in Fort Randall Reservoir varied longitudinally from the dam to the reservoir's upper reaches and vertically from the reservoir surface to the bottom (Plates 218 - 221). Dissolved oxygen levels below 5 mg/l first appeared near the reservoir bottom in the lower reaches of the reservoir in July (Plate 219). In August, dissolved oxygen levels below 2 mg/l were present near the reservoir bottom in the area near the dam (Plate 220). No dissolved oxygen concentrations below 5 mg/l were monitored in September of 2007 (Plate 221). This is attributed to the breakdown of thermal stratification that allowed the lacustrine area of the reservoir to mix throughout the water column.

5.6.2.1.3.2 Near-Dam Dissolved Oxygen Depth-Profile Plots

Dissolved oxygen levels exhibited occasional gradients with depth (Plate 222). On six occasions (i.e., August 27, 2003; August 3, 2004; August 17, 2005; July 20, 2006; July 19, 2007; and August 16, 2007), hypolimnetic dissolved concentrations fell below 5.0 mg/l. Dissolved oxygen levels below 5 mg/l occurred near the reservoir bottom from mid-July through August, when thermal stratification was maintained in Fort Randall Reservoir.

5.6.2.1.4 Water Clarity

5.6.2.1.4.1 Secchi Transparency

Figure 5.9 displays a box plot of the Secchi depth transparencies measured at the seven in-reservoir monitoring sites during 2006 and 2007 (note: the seven monitoring sites are oriented in an upstream to downstream direction along the x-axis). Secchi depth transparency decreased somewhat from site FTRLK0968DW to FTRLK0955DW (Figure 5.9). This is attributed to the inflow of suspended sediment from the White River just upstream of site FTRLK0955DW at RM956. Secchi depth transparency increased in a downstream direction from site FTRLK0955DW to site FTRLK0880A (Figure 5.9). This is attributed to suspended sediment from the inflow of the Missouri and White Rivers settling out in the reservoir as current velocities slow. The surface waters near Fort Randall Dam are significantly clearer than the upstream regions of the reservoir (Figure 5.9). Under the conditions that were monitored during 2007, it appears that sites FTRLK0968DW, FTRLK0955DW, and FTRLK0940DW were in the riverine zone; site FTRLK0924DW was in the transition zone; and sites FTRLK0911DW, FTRLK0892DW, and FTRLK0880A were in the lacustrine zone of Fort Randall Reservoir.

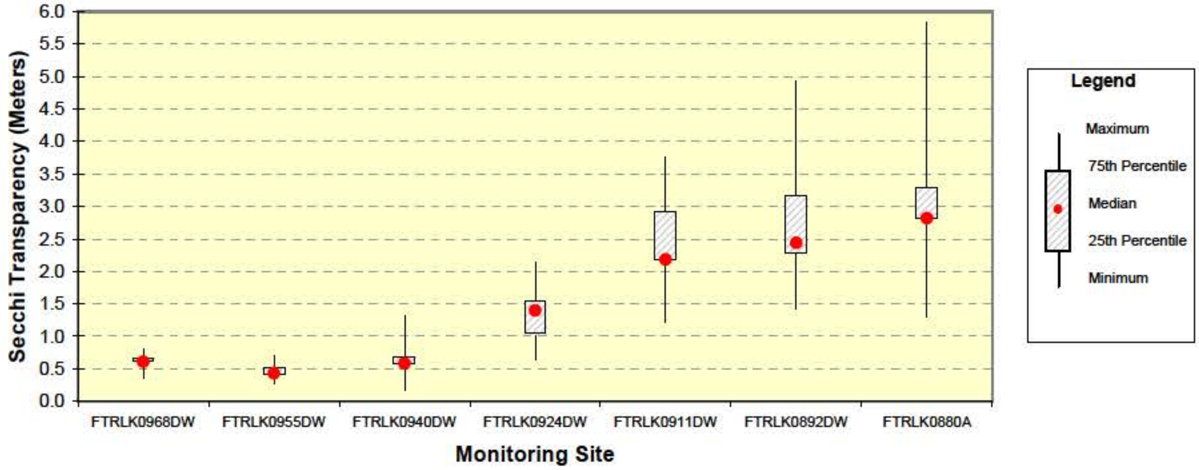

Figure 5.9. Box plot of Secchi transparencies measured in Fort Randall Reservoir during the 2-year period 2006 through 2007. (Note: monitoring sites are oriented on the x-axis in an upstream to downstream direction.)

5.6.2.1.4.2 Turbidity

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level. Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. Given the low chlorophyll *a* concentrations monitored in Fort Randall Reservoir (Plates 206 - 212), turbidity in the reservoir appears to be largely due to suspended inorganic material. Monthly (i.e., June through September) longitudinal contour plots were prepared from the depth-profile turbidity measurements taken at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 during 2007 (Plates 223 - 226). As seen in Plates 223 through 226, turbidity levels in Fort Randall Reservoir vary longitudinally from the dam to reservoir's upper reaches and vertically from the reservoir surface to the bottom. During periods of higher flows, the inflow of the White River has a significant impact on turbidity levels in the middle-upper reaches of the reservoir (Plates 224 - 226). It also appears that turbidity plumes may move along the reservoir bottom downstream of the confluence of the White River.

5.6.2.1.5 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Fort Randall Reservoir at the near-dam, deepwater area (i.e., site FTRLK0880A) during the summer over the 5-year period 2003 through 2007 were compared. Near-surface samples were taken to be samples collected within 2 meters of the reservoir surface, and near-bottom samples were taken to be samples collected within 2 meters of the reservoir bottom. Box plots were used to display the distribution of paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 227). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. No parameter significantly varied between the surface and bottom (Plate 227).

5.6.2.1.6 Reservoir Trophic Status

Trophic State Index (TSI) values for Fort Randall Reservoir were calculated from monitoring data collected during 2006 and 2007 (Table 5.14). The calculated TSI values indicate that the lacustrine zone of the reservoir (i.e., sites FTRLK0880A and FTRLK0911DW) is mesotrophic, and the transition zone (i.e., site FTRLK940DW) and the riverine zone (i.e., site FTRLK0968DWDW) is eutrophic. However, it is noted that the calculated average TSI values for the transition and riverine zones are greatly influenced by the low water clarity in this part of the reservoir. This lack of water clarity is largely attributed to suspended inorganic material delivered to the reservoir by the White River. Thus, the higher TSI values in this part of the reservoir seemingly are not indicative of increased algal growth associated with nutrient enrichment.

Table 5.14. Mean Trophic State Index (TSI) values calculated for Fort Randall Reservoir. TSI values are based on monitoring at the identified four sites during 2006 and 2007.

Monitoring Site	Mean – TSI (Secchi Depth)	Mean – TSI (Total Phos.)	Mean – TSI (Chlorophyll)	Mean – TSI (Average)
FTRLK0880A	46	52	44	47
FTRLK0911DW	49	49	52	51
FTRLK0940DW	69	53	59	60
FTRLK0968DW	68	56	54	59

Note: See Section 4.1.4 for discussion of TSI calculation.

5.6.2.1.7 Phytoplankton Community

Phytoplankton grab samples collected from Fort Randall Reservoir at sites FTRLK0880A, FTRLK0911DW, FTRLK0940DW, and FTRLK0968DW during the spring and summer of the 4-year period 2004 through 2007 are summarized in Plates 228 through 231. The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta > Cyanobacteria > Chrysophyta/Cryptophyta/Pyrrophyta > Euglenophyta. The diatoms were generally the most abundant algae based on percent composition (Plates 228 - 231). The Shannon-Weaver genera diversity indices calculated for the 41 phytoplankton samples collected at the four sites ranged from 0.44 to 2.86 and averaged 1.46 at site FTRLK0880A, 1.67 at site FTRLK0911DW, 1.95 at site FTRLK0940DW, and 1.75 at site FTRLK0968DW. Dominant phytoplankton taxa occurring in the 18 samples collected at site FTRLK0880A included the Bacillariophyta *Fragilaria spp.* (14 occasions), *Asterionella spp.* (5 occasions), *Aulacoseira spp.* (5 occasions), *Stephanodiscus spp.* (4 occasions), *Cyclotella spp.* (2 occasions), *Synedra spp.* (2 occasions), *Tabellaria spp.* (2 occasions), and *Melosira spp.* (1 occasion); Chlorophyta *Pyramichlamys* (1 occasion); Cryptophyta *Rhodomonas spp.* (4 occasions) and *Cryptomonas spp.* (2 occasions); Cyanobacteria *Oscillatoria spp.* (1 occasion) and *Planktolyngbya spp.* (1 occasion); and Pyrrophyta *Ceratium spp.* (3 occasions) (Plate 232). The highest concentration of the Cyanobacteria microcystins toxin measured at the four sites during the 3-year-period 2005 through 2007 was 1.8 ug/l at site FTRLK0880A.

5.6.2.2 Water Quality Trends (1980 through 2007)

Water quality trends over the period of 1980 through 2007 were determined for Fort Randall Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through October at the near-dam, ambient monitoring site (i.e., site FTRLK0880A). Plate 233 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. It appears that the reservoir exhibited decreasing levels of transparency (i.e. Secchi depth) and chlorophyll *a* and no appreciable trend in total phosphorus. Over the 28-year period, Fort Randall Reservoir has generally remained in a mesotrophic state with calculated TSI values showing no observable trend (Plate 233).

5.6.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI RIVER INFLOW TO FORT RANDALL RESERVOIR

5.6.3.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

The water quality conditions of the Missouri River inflow to Fort Randall Reservoir is taken to be the monitored water quality conditions of the outflow from Big Bend Dam. See Plate 186 for a summary of the water quality conditions monitored on the water discharged through Big Bend Dam.

5.6.3.2 Missouri River Inflow Nutrient Flux Conditions

Nutrient flux rates for the Missouri River inflow to Fort Randall Reservoir over the last 3 years were calculated based on water quality conditions monitored on water discharged through Big Bend Dam (i.e. site BBDPP1) (Table 5.15). The maximum nutrient flux rates are attributed to higher flows during maximum power production at Big Bend Dam.

Table 5.15. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Big Bend Dam (i.e., site BBDPP1) over the 4-year period 2004 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	33	33	33	33	18	32
Mean	0.049	0.336	0.018	0.022	0.009	2.476
Median	0.026	0.296	n.d.	0.013	n.d.	2.133
Minimum	n.d.	n.d.	n.d.	n.d.	n.d.	0.316
Maximum	0.219	0.878	0.266	0.115	0.047	6.115

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 28,105 cfs, median = 23,600 cfs, minimum = 3,600 cfs, and maximum = 71,980 cfs.

5.6.3.3 Mean Daily Discharge and Temperature

Mean daily discharge and water temperature of the Big Bend Dam outflow were determined for 2005, 2006, and 2007. These are considered the water quality conditions of the Missouri River inflow to Fort Randall Reservoir. Plates 234 through 236, respectively, plot 2005, 2006, and 2007 mean daily water temperature and flow for the Big Bend Dam discharge, respectively.

5.6.4 WATER QUALITY AT THE FORT RANDALL POWERPLANT

5.6.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 237 summarizes the water quality conditions that were monitored on water discharged through Fort Randall Dam during the 4-year period 2004 through 2007. A review of these results indicated no major water quality concerns.

5.6.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time series plots for temperature and dam discharge monitored at the Fort Randall powerplant during the 4-year period of 2004 through 2007 were constructed (Plates 238 - 245). Monitored water temperatures showed seasonal cooling and warming through each calendar year. Daily water temperatures remained fairly stable during the winter, early spring, and late fall and exhibited considerable variability during the late spring, summer, and fall. When thermal stratification becomes established in Fort Randall Reservoir during the late spring, the temperature of the water discharged through the dam becomes highly dependent upon the discharge rate of the dam. This indicates that the vertical extent of the withdrawal zone in the reservoir is dependent upon the discharge rate of the dam. This is believed to be a result of the design of the intake structure (i.e., bottom withdrawal) and the presence of the submerged approach channel leading to the intake structure. Water is likely drawn from an extended vertical zone in Fort Randall Reservoir year-round, but is only evident in the temperatures monitored at the powerhouse during reservoir thermal stratification during the summer. When thermal stratification breaks down in the summer, the high correlation between dam discharge and the temperature of the discharged water no longer occurs. This occurred in mid-August in 2004 (Plate 239), September 1, 2005 (Plate 241), late-July in 2006 (Plate 2006), and September 1, 2007 (Plate 245).

Semiannual time series plots for dissolved oxygen and dam discharge monitored at the Fort Randall powerplant during the 4-year period of 2004 through 2007 were also constructed (Plates 246 - 253). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall. The lowest dissolved oxygen levels occurred during the summer. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The decreasing dissolved oxygen in the summer is attributed to ongoing degradation of dissolved oxygen in the lower hypolimnion as the summer progressed. Water is withdrawn from Fort Randall Reservoir into the dam's power tunnels approximately 2 feet above the reservoir bottom. During the summer when Fort Randall Reservoir is thermally stratified, dissolved oxygen levels degrade near the reservoir bottom. Under such conditions, low dam discharge rates pull water with low dissolved oxygen concentrations from the near-bottom region of the hypolimnion.

During the period 2004 through 2007, 27,675 hourly measurements of dissolved oxygen were recorded. Of these measurements, 563 were less than 5 mg/l dissolved oxygen (2% of total measurements). Most of the recorded dissolved oxygen measurements less than 5 mg/l occurred in August of all four years (Plates 247, 249, 251, and 253). The low dissolved oxygen measurements were associated with low- or no-flow discharge conditions. The no-flow conditions are believed to be measurements of "static water" in the penstocks that is not being continuously discharged. This water is believed to have been drawn into the penstocks along the reservoir bottom as power generation was ramped down. The lowest dissolved oxygen concentration recorded was 2.0 mg/l on August 25 and 26, 2007. Seemingly, the low dissolved oxygen levels are related to oxygen degradation in the hypolimnion during late summer. During periods of lower discharge, water is drawn along the bottom of the submerged approach channel to the dam's intake tower. This is where low dissolved oxygen would occur in the hypolimnion during mid- to late summer.

5.6.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Fort Randall Reservoir

Plates 254 through 256, respectively, plot the mean daily water temperatures monitored for the Missouri River at Big Bend Dam (site BBDPP1) and the Fort Randall Dam powerplant (site FTRPP1) for 2005, 2006, and 2007. Inflow temperatures of the Missouri River to Fort Randall tend to be at little warmer than the outflow temperatures of Fort Randall Dam during the spring and early summer (Plates 254 - 256). Outflow temperatures of the Fort Randall Dam discharge tend to be a little warmer than the Missouri River inflow temperatures in the late-summer and fall (Plates 254 - 256).

5.6.5 WATER QUALITY IN THE MISSOURI RIVER DOWNSTREAM OF FORT RANDALL DAM

5.6.5.1 Missouri River Reach – Fort Randall Dam to Gavins Point Reservoir

The Missouri River downstream from Fort Randall Dam (RM880.0) flows in a southeasterly direction for approximately 44 miles in an unchannelized river to Gavins Point Reservoir. The major tributary in this reach is the Niobrara River which enters the Missouri River from Nebraska at RM843.5. In this reach, the Missouri River meanders in a wide channel with flow restricted to generally one main channel. Only a few side channels and backwaters are present, except at the lower end of the reach in the Gavins Point Reservoir delta. The 39-mile reach of the Missouri River from Fort Randall Dam to Running Water, SD has been designated a National Recreational River under the Federal Wild and Scenic Rivers Act (WSRA). The tailwater area of Fort Randall Dam, from RM 880 to 860, has experienced up to 6 feet of riverbed degradation and channel widening during the 1953 to 1997 time period. The rate of erosion has decreased over this period. Streambank erosion since closure of the dam in 1953 has averaged about 35 acres per year. This compares to a pre-dam rate of 135 acres per year. The Missouri River has coarser bed material above RM 870 than below, indicating some armoring of the channel below the dam. Downstream of the tailwater area, less erosion of the bed and streambank occurs.

5.6.5.1.1 National Recreation River Designation Pursuant to the Federal Wild and Scenic Rivers Act

The 39-mile "natural-channel" reach of the Missouri River from Fort Randall Dam to the headwaters of Gavins Point Reservoir has been designated as a National Recreational River under the Federal WSRA. The National Park Service (NPS) manages the 39-mile reach pursuant to the WSRA. The justification that supported that this reach of the Missouri River be protected as a recreational river identified its outstanding remarkable recreational, fish and wildlife, aesthetic, historical, and cultural values. Under the WSRA, the U.S. Department of Interior (i.e., NPS) is mandated to administer this reach in a manner that will protect and enhance these values for the benefit and enjoyment of present and future generations.

5.6.5.1.2 State Designations and Listings Pursuant to the Federal Clean Water Act

Pursuant to the Federal Clean Water Act, the States of South Dakota and Nebraska have designated water quality-dependent beneficial uses, in their State water quality standards, for the Missouri River from of Fort Randall Dam to Gavins Point Reservoir. South Dakota has designated the following uses for this reach of the Missouri River: primary contact recreation, warmwater fishery, drinking water supply, and industrial water supply. Nebraska has designated the following uses to this reach of the Missouri River: primary contact recreation, warmwater aquatic life, agricultural water supply, and aesthetics. It has designated the use of drinking water supply to the river below the confluence of the Niobrara River. Nebraska has also designated the reach between the Nebraska-South Dakota border and

Gavins Point Reservoir an Outstanding State Resource Water for "Tier 3" protection under the State's water quality standard's antidegradation policy.

5.6.5.2 Monitored Water Quality Conditions

The District, in cooperation with the Nebraska Department of Environmental Quality, conducted fixed-station water quality monitoring at two sites along the Missouri River from Fort Randall Dam to Gavins Point Reservoir. The locations of the two sites were Fort Randall Dam tailwaters (site FTRRRTW1) and the Missouri River near Verdel, NE (site MORRR0851) (see Figure 5.10). During the 5-year period of 2003 through 2007, water quality samples were collected monthly from October through March and biweekly from April through September. Plates 257 and 258 summarize the water quality conditions that were monitored at the two sites. A review of these results indicated no major water quality concerns.

5.7 GAVINS POINT

5.7.1 BACKGROUND INFORMATION

5.7.1.1 Project Overview

Gavins Point Dam is located on the Missouri River at RM 811.1 on the South Dakota-Nebraska border in southeast South Dakota and northeast Nebraska, 4 miles west of Yankton, SD. The closing of Gavins Point Dam in 1955 resulted in the formation of Gavins Point Reservoir (Lewis and Clark Lake). The reservoir is 25 miles long, covers 31,000 acres, and has 90 miles of shoreline when full. Table 5.16 summarizes how the surface area, volume, mean depth, and retention time of Gavins Point Reservoir vary with pool elevations. Gavins Point Reservoir is normally regulated near 1206.0 ft-msl in the spring and early summer with variations day to day due to rainfall runoff. The reservoir level is then increased to elevation 1207.5 ft-msl following the least tern and piping plover nesting season for reservoir recreation enhancement. Major inflows to Gavins Point Reservoir are the Missouri River and Niobrara River. Water discharged through Gavins Point Dam for power production is withdrawn at the surface of the reservoir.

Gavins Point was authorized for the proposes of flood control, recreation, fish and wildlife, hydroelectric power production, water supply, water quality, navigation, and irrigation. The powerplant has three generating units that produce an annual average 0.734 million megawatt hours of electricity, valued in excess of $12 million in revenue. Habitat for two endangered species, pallid sturgeon and interior least tern, and one threatened species, piping plover, occur within the project area. Gavins Point Reservoir is used as a water supply by the cities of Bon Homme, Springfield, and Cedar, SD. Gavins Point is an important recreational resource and a major visitor destination in South Dakota and Nebraska.

5.7.1.2 Water Quality Standards Classifications and Section 303(d) Listings

5.7.1.2.1 Gavins Point Reservoir

Pursuant to the Federal Clean Water Act, the State of South Dakota has designated the following water quality-dependent beneficial uses for Gavins Point Reservoir: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, domestic water supply, agricultural water supply (i.e., irrigation and stock watering), commerce and industrial waters, and fish and wildlife propagation. The State of Nebraska has designated the following beneficial uses to Gavins Point Reservoir: primary contact recreation, Class I warmwater aquatic life, drinking water supply, agricultural water supply, industrial water supply, and aesthetics. The uses designated by the States of South Dakota

Table 5.16. Surface area, volume, mean depth, and retention time of Gavins Point Reservoir at different pool elevations.

Elevation (Feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Mean Depth (Feet)*	Retention Time (Years)**
1210	30,880	469,928	15.2	0.02365
1205	24,296	332,842	13.7	0.01675
1200	19,713	223,547	11.3	0.01125
1195	14,871	137,085	9.2	0.00690
1190	10,276	74,110	7.2	0.00373
1185	5,283	36,442	6.9	0.00183
1180	3,486	15,631	4.5	0.00079
1175	1,133	4,543	4.0	0.00023
1170	451	1,053	2.3	0.00005

Average Annual Inflow (1967 through 2007) = 19.96 Million Acre-Feet.
Average Annual Outflow: (1967 through 2007) = 19.87 Million Acre-Feet.
* Mean Depth = Volume ÷ Surface Area.
** Retention Time = Volume ÷ Average Annual Outflow.
Note: Exclusive Flood Control Zone (elev. 1210-1208 ft-msl), Annual Flood Control and Multiple Use Zone (elev. 1208-1204.5 ft-msl), Carryover Multiple Use Zone (none), and Permanent Pool Zone (elev. 1204.5-1160 ft-msl). All elevations are in the NGVD 29 datum.

and Nebraska to Gavins Point Reservoir are consistent with each other. Neither of the two States has placed Gavins Point Reservoir on the State's Section 303(d) list of impaired waters, or has issued fish consumption advisories for the reservoir.

5.7.1.2.2 Missouri River Downstream of Gavins Point Dam

See Section 6 for a discussion of the Lower Missouri River downstream of Gavins Point Dam.

5.7.1.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at the Gavins Point Project since the late 1970's. Water quality monitoring locations have included sites on the reservoir and on the outflow from the reservoir. Figure 5.10 shows the location of sites at the Gavins Point Project that have been monitored for water quality during the 5-year period 2003 through 2007. The near-dam location (i.e., site GPTLK0811A) has been continuously monitored since 1980.

5.7.2 WATER QUALITY IN GAVINS POINT RESERVOIR

5.7.2.1 Existing Water Quality Conditions (2003 through 2007)

5.7.2.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 259 summarizes the water quality conditions that were monitored in Gavins Point Reservoir at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) during the 5-year period 2003 through 2007. A review of these results indicated possible water quality concerns regarding dissolved oxygen and nutrients. Based on the criteria for the protection of warmwater aquatic life propagation, 8% of the observations did not meet dissolved oxygen criterion of 5 mg/l. The dissolved oxygen measurements that were below the criterion occurred near the reservoir bottom in the hypolimnion during the summer on occasions when the reservoir was thermally stratified. Nebraska's dissolved oxygen criteria are not applicable to the hypolimnion when lakes are thermally stratified. The

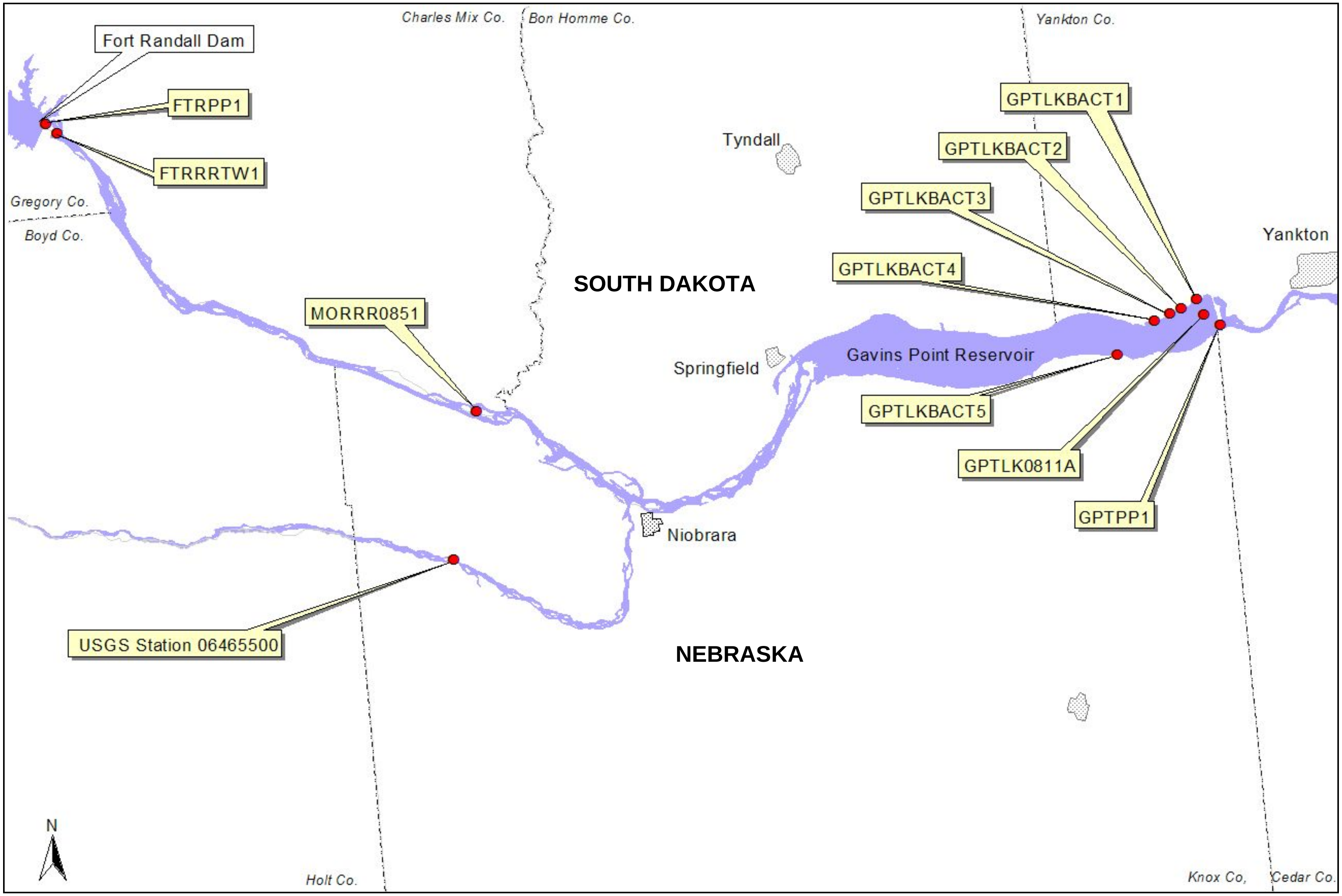

Figure 5.10. Location of sites where water quality monitoring was conducted by the District at the Gavins Point Project during the period 2003 through 2007.

Nebraska nutrient criteria applicable to Gavins Point Reservoir, a classified R9 reservoir, were regularly exceeded. The chlorophyll *a*, total nitrogen, and total phosphorus criteria were exceeded by, respectively, 35, 25, and 21 percent of the observations for these parameters.

5.7.2.1.2 Summer Thermal Stratification

Existing summer thermal stratification was assessed for Gavins Point Reservoir, based on monitoring results obtained at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) during the 5-year period 2003 through 2007. Temperature-depth profiles were constructed from water quality data collected during the summer months (Plate 260). It appears a slight temperature-depth gradient (i.e., less than 5°C from reservoir surface to bottom) occasionally occurs in Gavins Point Reservoir in the near-dam lacustrine area during the summer (Plate 260). When this slight stratification occurs, a thermocline is present at about 8 meters depth. This indicates the reservoir is probably polymixic. During periods of calm weather in the summer, Gavins Point Reservoir will develop a slight thermal stratification. The thermal stratification breaks down under windier conditions, given the shallow depth of the reservoir (i.e., 15 meters), and the reservoir mixes throughout its water column.

5.7.2.1.3 Summer Dissolved Oxygen Conditions

Existing summer dissolved oxygen conditions were assessed for Gavins Point Reservoir, based on monitoring results obtained at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) during the 5-year period 2003 through 2007. Dissolved oxygen depth profiles were constructed from water quality data collected during the summer months (Plate 261). The measured summer dissolved oxygen-depth profiles were quite variable, exhibiting little to significant differences in dissolved oxygen levels with depth. The lower dissolved oxygen concentrations were measured near the reservoir bottom. The variability of the summer dissolved oxygen-depth profiles is attributed to the polymictic nature of the reservoir. When thermal stratification of the reservoir does develop in the summer, significant dissolved oxygen degradation occurs in the near-bottom area of the hypolimnion. The lowest dissolved oxygen concentration measured was 1.4 mg/l and was measured near the reservoir bottom on July 21, 2006.

5.7.2.1.4 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Gavins Point Reservoir at the near-dam, deepwater area (i.e., site GPTLK0811A) during the summer over the 5-year period 2003 through 2007 were compared. Near-surface samples were taken to be samples collected within 1 meter of the reservoir surface, and near-bottom samples were taken to be samples collected within 1 meter of the reservoir bottom. Box plots were used to display the distribution of paired near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon (Plate 262). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. No parameter significantly varied between the surface and bottom; however, near-bottom dissolved oxygen levels were nearly significantly lower than near-surface levels (Plate 262).

5.7.2.1.5 Reservoir Trophic Status

Trophic State Index (TSI) values for Gavins Point Reservoir were calculated from monitoring data collected during the 5-year period of 2003 through 2007 at site GPTLK0811A. Table 5.17 summaries the TSI values calculated for the reservoir. The TSI values indicate that the near-dam lacustrine area of Gavins Point Reservoir is in a eutrophic state.

Table 5.17. Summary of Trophic State Index (TSI) values calculated for Gavins Point Reservoir for the 5-year period 2003 through 2007.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	25	63	62	53	71
TSI(TP)	24	54	55	41	72
TSI(Chl)	24	56	58	40	66
TSI(Avg)	25	57	57	49	67

* TSI(SD), TSI(TP), and TSI(Chl) are TSI index values based, respectively, on Secchi depth, total phosphorus, and chlorophyll *a* measurements. TSI(Avg) is the average of the individual parameter TSI values.
Note: See Section 4.1.4 for discussion of TSI calculation.

5.7.2.1.6 Phytoplankton Community

Phytoplankton grab samples collected from Gavins Point Reservoir at site GPTLK0811A during the spring and summer of the 4-year period 2004 through 2007 are summarized in Plate 263. The following seven taxonomic divisions were represented by taxa collected in the phytoplankton samples: Bacillariophyta (Diatoms), Chlorophyta (Green Algae), Chrysophyta (Golden Algae), Cryptophyta (Cryptomonad Algae), Cyanobacteria (Blue-Green Algae), Pyrrophyta (Dinoflagellate Algae), and Euglenophyta (Euglenoid Algae). The general prevalence of these taxonomic divisions in the reservoir, based on taxa occurrence, were Bacillariophyta > Chlorophyta > Cyanobacteria > Cryptophyta/Euglenophyta/Pyrrophyta > Chrysophyta. The diatoms were generally the most abundant algae based on percent composition (Plate 263). The Shannon-Weaver genera diversity indices calculated for the 18 phytoplankton samples collected at site GPTLK0811A averaged 1.74. Dominant phytoplankton species occurring in the 18 samples collected at site GPTLK0811A included the Bacillariophyta *Fragilaria spp.* (13 occasions), *Aulacoseira spp.* (9 occasions), *Stephanodiscus spp.* (6 occasions), *Asterionella spp.* (2 occasions), and *Cyclotella spp.* (2 occasions); Cryptophyta *Rhodomonas spp.* (4 occasions) and *Cryptomonas spp.* (2 occasions); Cyanobacteria *Anabaenposis spp.* (1 occasion), *Aphanocapsa spp.* (1 occasion), and *Aphanothece spp.* (1 occasion); and Pyrrophyta *Ceratium spp.* (1 occasion) and *Peridinium spp.* (1 occasion) (Plate 264). No detectable concentrations of the microcystins toxin were monitored at site GPTLK0811A during 2005 through 2007 (Plate 259).

5.7.2.1.7 Bacteria Monitoring at Swimming Beaches on Gavins Point Reservoir

During the 5-year period 2003 through 2007, bacteria samples were collected weekly from May through September at five swimming beaches located on Gavins Point Reservoir. The five swimming beaches where the bacteria samples were collected were: Weigand Recreation Area (site GPTLKBACT5), Gavins Point Recreation Area (site GPTLKBACT4), Lewis and Clark Recreation Area – Midway West Beach (site GPTLKBACT3), Lewis and Clark Recreation Area Midway East Beach (GPTLKBACT2), and the Marina Sailing Boat Area (site GPTLKBACT1) (Figure 5.10). Table 5.18 summarizes the results of the bacteria sampling. The geometric means were calculated as running geometric means for five consecutive weekly bacteria samples and nondetects were set to 1. The bacteria sampling results were compared to following bacteria criteria for support of "full-body contact" recreation:

<u>Fecal Coliform:</u>
Bacteria of the fecal coliform group should not exceed a geometric mean of 200/100ml, nor equal or exceed 400/100ml, in more than 10% of the samples. These criteria are based on a minimum of five samples taken within a 30-day period.

<u>*E. coli*</u>:

E. coli bacteria should not exceed a geometric mean of 126/100ml. For increased confidence of the criteria, the geometric mean should be based on a minimum of five samples taken within a 30-day period. Single sample maximum allowable density for designated bathing beaches is 235/100ml.

Based on these criteria, "full-body contact" recreation was fully supported at the five sampled swimming beaches on Gavins Point Reservoir during the May through September recreational season during the 5-year period of 2003 through 2007. It is noted that 2 percent of the observations at site GPTLKBACT5 (Weigand Recreation Area) exceeded the geometric mean criteria.

Table 5.18. Summary of weekly (May through September) bacteria sampling conducted at five swimming beaches on Gavins Point Reservoir over the 5-year period 2003 through 2007.

	Weigand Recreation Area (GPTLKBACT5)	**Gavins Point Recreation Area (GPTLKBACT4)**	**Lewis & Clark Rec. Area Midway West (GPTLKBACT3)**	**Lewis & Clark Rec. Area Midway East (GPTLKBACT2)**	**Marina Sailing Boat Area (GPTLKBACT1)**
<u>**Fecal Coliform Bacteria:**</u>					
Number of Samples	105	106	106	106	106
Mean	190	53	32	37	34
Median	30	14	9	9	4
Minimum	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum	7,500	780	370	400	520
Percent of samples exceeding 400/100ml	5%	4%	0%	0%	1%
• **Geometric Mean**					
Number of Geomeans	86	86	86	87	86
Average	34	17	11	12.4	9
Median	25	13	8	8	7
Minimum	2	n.d.	n.d.	n.d.	n.d.
Maximum	220	66	69	67	39
Number of Geomeans exceeding 200/100ml	2%	0%	0%	0%	0%
<u>***E. coli* Bacteria**</u>					
Number of Samples	104	105	105	105	105
Mean	101	30	24	20	23
Median	14	10	6	4	2
Minimum	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum	4,679	450	387	250	340
Percent of samples exceeding 235/100ml	6%	1%	2%	1%	1%
• **Geomean**					
Number of Geomeans	86	86	86	87	86
Average	22	10	7	7	5
Median	14	7	6	6	4
Minimum	2	2	n.d.	n.d.	n.d.
Maximum	193	36	26	26	21
Number of Geomeans exceeding 126/100ml	2%	0%	0%	0%	0%

n.d. = Not detected.

Note: Not detected values set to 1 to calculate mean and geometric mean.

5.7.2.2 Water Quality Trends (1980 through 2007)

Water quality trends over the period of 1980 through 2007 were determined for Gavins Point Reservoir for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the reservoir during the months of May through October at the near-dam monitoring site (i.e., site GPTLK0811A). Plate 265 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. For the assessment period, it appears that Gavins Point Reservoir exhibited increasing concentrations of total phosphorus and decreasing levels of transparency (i.e. Secchi depth). A decreasing trend is indicated for chlorophyll *a*, however; two possible outliers in the late 1980's are the sole cause for this trend. If these potential outliers are removed there is no observable trend in chlorophyll *a*. Over the 28-year period, the reservoir has generally remained in a moderately eutrophic to eutrophic state with calculated TSI values showing no observable trend (Plate 265).

5.7.3 EXISTING WATER QUALITY CONDITIONS OF THE MISSOURI AND NIOBRARA RIVER INFLOWS TO GAVINS POINT RESERVOIR

5.7.3.1 Missouri River above the Confluence of the Niobrara River

5.7.3.1.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

The water quality conditions of the Missouri River above the confluence of the Niobrara River are defined by the water quality conditions monitored in the outflow from Fort Randall Dam (site FTRPP1), in the Fort Randall Dam tailwaters (site FTRRRTW1), and in the Missouri River near Verdel, NE (site MORRR0851). Plates 237, 257, and 258, respectively, summarize water quality conditions monitored at these three sites over the 5-year period 2003 through 2007.

5.7.3.1.2 Nutrient Flux Conditions

The nutrient flux rates of the Missouri River above the confluence of the Niobrara River, over the 5-year period 2003 through 2007, were calculated from water quality conditions monitored in the Missouri River near Verdel, NE (i.e., site MORRR0851) (Table 5.19). The maximum nutrient flux rates are attributed to higher flows during maximum power production at Fort Randall Dam.

Table 5.19. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River near Verdel, NE (i.e., site MORRR0851) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	81	81	81	80	-----	79
Mean	0.091	0.286	0.009	0.026	-----	3.579
Median	0.043	0.213	n.d.	0.014	-----	3.306
Minimum	n.d.	n.d.	n.d.	n.d.	-----	1.738
Maximum	0.923	1.846	0.154	0.231	-----	14.191

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 22,906 cfs, median = 24,551cfs, minimum = 3,981 cfs, and maximum = 41,299 cfs.

5.7.3.1.3 Mean Daily Discharge and Temperature

Mean daily discharge and water temperature of the Fort Randall Dam outflow were determined for 2005, 2006, and 2007. These are considered the water quality conditions of the Missouri River above the confluence of the Niobrara River. Plates 266, 267, and 268, respectively, plot 2005, 2006, and 2007 mean daily water temperature and flow for the Fort Randall Dam discharge.

5.7.3.2 Niobrara River

5.7.3.2.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

The Nebraska Department of Environmental Quality (NDEQ) maintains an ambient water quality monitoring site on the Niobrara near Verdel, Nebraska at USGS gaging station 06465500 (Figure 5.10). The water quality conditions that were monitored by the NDEQ in the Niobrara River at this site are summarized in Plate 269. A review of these results indicated no significant water quality concerns.

5.7.3.2.2 Nutrient Flux Conditions

The nutrient flux rates of the Niobrara River above the confluence of the Missouri River, over the period 2003 through 2007, were calculated from water quality conditions monitored in the Niobrara River near Verdel, Nebraska (i.e., site USGS 06465500) (Table 5.20). The maximum nutrient flux rates are attributed to greater nonpoint-source nutrient loadings associated with runoff conditions.

Table 5.20. Summary of nutrient flux rates (kg/sec) calculated for the Niobrara River near Verdel, NE (i.e., site USGS 06465500) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	75	75	75	75	-----	-----
Mean	0.003	0.055	0.042	0.019	-----	-----
Median	0.001	0.036	0.036	0.009	-----	-----
Minimum	n.d.	n.d.	n.d.	n.d.	-----	-----
Maximum	0.080	1.217	0.404	0.469	-----	-----

Note 1: Non-detect values set to 0 for flux calculations.
Note 2: Statistics of Niobrara River flows used for flux calculations were: mean = 1,822 cfs, median = 1,500 cfs, minimum = 674 cfs, and maximum = 11,600 cfs.

5.7.3.2.3 Continuous Water Temperature Monitoring of the Niobrara River at the USGS Gaging Station near Verdel, NE

Through an agreement with the USGS, a water temperature monitoring probe was added to the USGS's gage on the Niobrara River near Verdel, NE (i.e., site USGS 06465500). Beginning in April 2005, hourly water temperature measurements were recorded at the site. Plates 270 through 272, respectively, plot mean daily water temperature and river discharge determined for 2005, 2006, and 2007.

5.7.3.3 Estimated Total Inflow Conditions

The water quality conditions of the Missouri River inflow to Gavins Point Reservoir are estimated from the water quality conditions of the Missouri River above its confluence with the Niobrara River, and the Niobrara River above its confluence with the Missouri River. Streamflow in the Missouri River below the confluence of the Niobrara River is estimated by adding streamflows in each river. Water quality conditions are estimated by flow-weighted averaging.

5.7.3.3.1 Inflow Nutrient Flux Conditions

The estimated nutrient flux rates of the Missouri River inflow to Gavins Point Reservoir are given in Table 5.21. The estimates in Table 5.21 were determined by flow-weighting the results provided in Tables 5.19 and 5.20. This assumes that mean, median, minimum, and maximum conditions in the Missouri and Niobrara Rivers represented in Tables 5.19 and 5.20 occur concurrently.

Table 5.21. Summary of nutrient flux rates (kg/sec) estimated for the Missouri River inflow to Gavins Point Reservoir over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Dissolved Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
Mean	0.085	0.267	0.011	0.025	-----	-----
Median	0.041	0.203	0.002	0.014	-----	-----
Minimum	n.d.	n.d.	n.d.	n.d.	-----	-----
Maximum	0.738	1.708	0.209	0.283	-----	-----

Note1: Values are flow-weighted averages of the values provided in Tables 5.19 and 5.20.
Note2: Statistics of added flows for the Missouri River inflow to Gavins Point Reservoir are: mean = 24,728 cfs, median = 26,051 cfs, minimum = 4,655 cfs, and maximum = 52,899 cfs.

5.7.3.3.2 Mean Daily Discharge and Temperature

The estimated mean daily discharge and temperature of the Missouri River inflow to Gavins Point Reservoir for 2005 through 2007 are plotted in Plates 273, 274, and 275. The mean daily discharge was estimated by adding the mean daily discharges determined for the Fort Randall Dam outflow and Niobrara River near Verdel, NE at USGS gaging station 06465500. The mean daily temperature was estimated by flow weighting the mean daily water temperatures determined at the two sites.

5.7.4 WATER QUALITY AT THE GAVINS POINT POWERPLANT

5.7.4.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 276 summarizes the water quality conditions that were monitored on water discharged through Gavins Point Dam during the period 2004 through 2007. A review of these results indicated no major water quality concerns.

5.7.4.2 Temperature, Dissolved Oxygen, and Dam Discharge Time-Series Plots

Semiannual time-series plots for temperature, dissolved oxygen, and dam discharge monitored at the Gavins Point powerplant during the 4-year period 2004 through 2007 were constructed. Water temperatures showed seasonal warming and cooling through each calendar year (Plates 277 - 284). Dissolved oxygen levels remained relatively high and stable during the winter, steadily declined through the spring and summer, and steadily increased during the fall (Plates 285 - 292). The lowest dissolved oxygen levels occurred during mid- to late July. The higher winter, declining spring, and increasing fall dissolved oxygen concentrations are attributed to decreasing dissolved oxygen solubility with warmer water temperatures. The lower dissolved oxygen concentrations in July may be associated with degradation in the hypolimnion when limited thermal stratification is able to become established. There appeared to be little correlation between discharge rates and measured water temperature and dissolved oxygen concentrations (Plates 277 - 292).

5.7.4.3 Comparison of Monitored Inflow and Outflow Temperatures of the Missouri River at Gavins Point Reservoir

Plates 293, 294, and 295, respectively, plot the mean daily water temperatures estimated for the Missouri River inflow to Gavins Point Reservoir and monitored at the Gavins Point Dam powerplant (site GTPPP1) for 2005, 2006, and 2007. Inflow temperatures of the Missouri River to Gavins Point Reservoir tend to be at little cooler than the outflow temperatures of Gavins Point Dam during the spring and early summer (Plates 293 - 295. Outflow temperatures of the Gavins Point Dam discharge tend to be a little warmer than the Missouri River inflow temperatures in the late-summer and fall (Plates 293 and 295).

5.8 COMPARISON OF EXISTING WATER QUALITY CONDITIONS AT THE MAINSTEM SYSTEM RESERVOIRS

The 5-year period of 2003 through 2007 was a period of severe drought in the western United States where the Mainstem System reservoirs are located. During this period, Mainstem System reservoirs experienced historic low pool elevations and water in storage dropped to 47 percent of the Mainstem System storage capacity. Reduced pool levels and reservoir volumes were especially pronounced at the upper three Mainstem System reservoirs: Fort Peck, Garrison, and Oahe. Drought induced reduction in reservoir volumes could reasonably be expected to have water quality ramifications due to reductions in the pollution assimilative capacity of the reservoirs and exposure of previously flooded sediments. The final impact of the existing drought on water quality conditions at the Mainstem System reservoirs is still to be determined; however, monitoring of existing water quality conditions does not indicate major concerns other than the maintenance of coldwater fishery habitat in Garrison Reservoir.

5.8.1 ATTAINMENT OF STATE WATER QUALITY STANDARDS

The attainment of water quality standards at the Mainstem System Projects, based on water quality conditions monitored over the 5-year period 2003 to 2007 by the District, is summarized in Table 5.21. Water quality standards attainment was defined as whether the designated beneficial uses in State water quality standards were supported based on the monitored water quality conditions. The following water quality standards attainment ratings were defined based on the percentage of the observations that exceed applicable water quality standards criteria: 1) Full Support (less than 10% of the observations exceed criteria), 2) Not Supported (greater than 20% of the observations exceed criteria), and 3) Threatened (10-20% of observations exceed criteria or greater 10% of the observations exceed criteria seasonally). It is noted that the “official” determination of whether water quality standards are being attained, pursuant to the Federal CWA is identified by the States pursuant to their Section 305(b) and Section 303(d) assessments (See Table 1.3).

Table 5.22. Summary of water quality standards attainment (i.e., support of designated beneficial uses) based on existing water quality conditions monitored at the Mainstem System projects over the 5-year period 2003 through 2007. (Note: "Official" water quality standards attainment is defined in State prepared Section 305(b) and Section 303(d) assessments – See Table 1.3.)

	Recreation[1]	**Coldwater Aquatic Life**	**Warmwater Aquatic Life**	**Domestic Water Supply**	**Agricultural Water Supply**	**Industrial Water Supply**
Fort Peck Reservoir	Unknown	Not Assigned[2]	Full Support	Full Support	Full Support	Full Support
Fort Peck Dam Tailwaters	Unknown	Full Support	Full Support	Full Support	Full Support	Full Support
Garrison Reservoir	Unknown	Threatened[3]	Full Support	Full Support	Full Support	Full Support
Garrison Dam Tailwaters	Unknown	Threatened[4]	Threatened[4]	Full Support	Full Support	Full Support
Oahe Reservoir	Unknown	Full Support	Full Support	Full Support	Full Support	Full Support
Oahe Dam Tailwaters	Unknown	Not Supported[5]	Full Support	Full Support	Full Support	Full Support
Big Bend Reservoir	Unknown	Not Supported[6]	Full Support	Full Support	Full Support	Full Support
Big Bend Dam Tailwaters	Unknown	Not Assigned	Full Support	Full Support	Full Support	Full Support
Fort Randall Reservoir	Unknown	Not Assigned	Full Support	Full Support	Full Support	Full Support
Fort Randall Dam Tailwaters	Unknown	Not Assigned	Full Support	Full Support	Full Support	Full Support
Gavins Point Reservoir	Full Support	Not Assigned	Full Support	Full Support	Full Support	Full Support
Gavins Point Dam Tailwaters	Unknown	Not Assigned	Full Support	Full Support	Full Support	Full Support

(1) Water quality standards attainment for recreation is based on assessment of collected bacteria data.

(2) The State of Montana has not assigned a coldwater aquatic life use to Fort Peck Reservoir. A coldwater fishery and associated aquatic life do exist in Fort Peck Reservoir and monitored water quality conditions indicate that it is currently fully supported.

(3) Coldwater aquatic life in Garrison Reservoir is currently threatened by warm water temperatures and low dissolved oxygen levels occurring in the hypolimnion during the late summer when reservoir pool levels fall below elevation 1825 ft-msl.

(4) Aquatic life uses in the Garrison Dam tailwaters may be threatened by low dissolved oxygen levels during late summer. Water discharged from Garrison Dam is drawn from the bottom of Garrison Reservoir. The reservoir thermally stratifies during the summer and the lower depths of the hypolimnion experience dissolved oxygen degradation as the summer progresses.

(5) Oahe Reservoir thermally stratifies in the summer and coldwater aquatic life is supported in the reservoir's hypolimnion. However, the power tunnel portals at Oahe Dam are located about 110 feet above the bottom of the reservoir and dam discharges during the summer commonly draw warmer water from the metalimnion and epilimnion – especially when pool elevations are low. Thus, water temperatures in the Oahe Dam tailwaters are not supportive of coldwater aquatic life during mid- to late summer.

(6) Big Bend Reservoir generally does not exhibit sharp thermal stratification in the summer; therefore, a coldwater hypolimnion does not usually form. The lack of significant summer thermal stratification at the reservoir is attributed to its relative shallowness and the high discharges released through Big Bend Dam associated with its operation to meet peak power demands. Due to the lack of significant summer thermal stratification, ambient water temperatures in Big Bend Reservoir are not cold enough to support coldwater permanent fish life propagation, as defined by State water quality criteria. Consideration should be given to reclassify Big Bend Reservoir for a warmwater permanent fish life propagation use based on a use attainability assessment of "natural conditions" regarding ambient water temperature.

5.8.2 GENERAL WATER QUALITY CONDITIONS IN THE RESERVOIRS

Table 5.22 summarizes general water quality conditions at the Mainstem System reservoirs based on the water quality monitoring conducted over the 5-year period 2003 through 2007. The four largest reservoirs (i.e., Fort Peck, Garrison, Oahe, and Fort Randall) exhibit characteristics typical of temperate zone dimictic lakes. These four reservoirs exhibit thermal stratification in the summer and winter separated by periods of complete mixing during the spring and fall turnover periods. A large quiescent hypolimnion forms during the summer in the three larger reservoirs (i.e., Fort Peck, Garrison, and Oahe) with a smaller hypolimnion forming in Fort Randall. The formation of a smaller hypolimnion in Fort Randall Reservoir, as compared to the three other reservoirs, is attributed to its lesser maximum depth and volume. Due to its shallower depth, Gavins Point Reservoir appears to be polymixic, with periods of summer thermal stratification forming and breaking down as climatic factors change. Big Bend Reservoir does not typically exhibit summer thermal stratification due to its shallower depth and high discharge rates that occur through Oahe and Big Bend Dams. Severe hypolimnetic dissolved oxygen degradation regularly occurs in Garrison Reservoir. Moderate hypolimnetic dissolved oxygen degradation occurs in Fort Randall Reservoir, while only minor hypolimnetic dissolved oxygen degradation appears to occur in Fort Peck and Oahe Reservoirs. Significant dissolved oxygen degradation can occur in Gavins Point Reservoir during the summer when thermal stratification persists. Water quality conditions of summer discharges from Garrison and Fort Randall Dams are highly correlated to dam discharge rates. This high degree of correlation of summer water quality conditions of discharged water with dam discharge rate is not evident at the other four Mainstem System dams. The high degree of correlation at Garrison and Fort Randall Dams is attributed to each dam having a near-bottom withdrawal from their impounded reservoirs. The vertical extent of the withdrawal zone in these two reservoirs is dependent on the dam discharge rate. The lacustrine areas of the five upper reservoirs all appear to be mesotrophic, with only Gavins Point being in a eutrophic condition. The prevalence of major phytoplankton groups is similar in all six Mainstem System reservoirs, with diatoms being the most prevalent group.

5.8.3 COMPARISON OF THE EXISTING COLDWATER HABITAT CONDITIONS IN FORT PECK, GARRISON, AND OAHE RESERVOIRS

5.8.3.1 Water Temperature

Near-bottom water temperatures measured at a near-dam, deepwater monitoring site in Fort Peck, Garrison, and Oahe Reservoirs during the period May through October of 2003 through 2007 were plotted to compare hypolimnetic water temperatures of the three reservoirs (Plate 296). In all 5 years, the near-bottom water temperatures measured in the three reservoirs were similar in May. The near-bottom temperature of all three reservoirs increased every year over the "summer" period. The relative rates at which the near-bottom water warmed in the three reservoirs remained consistent over the 5 years; Garrison had the highest rate of warming, Oahe had the lowest, and the rate of warming of Fort Peck was in between (Plate 296).

Water temperature-depth profiles measured at the near-dam, deepwater locations at the three reservoirs were used to determine the depth at which water temperatures of 15°C or less occurred. Plate 297 shows a plot of the 15°C water temperature isopleths for Fort Peck, Garrison, and Oahe Reservoirs for 2003 through 2007. All three reservoirs exhibited surface water temperatures at or below 15°C in May of all 5 years (Plate 297). After May of each year, the 15°C isopleths in all three reservoirs generally moved downward (i.e., 15°C water temperature occurred at a greater depth) through the "summer" period until fall turnover of the reservoirs occurred (Plate 258). The rate of decline of the 15°C isopleths at Garrison was greater than at Fort Peck and Oahe in 2003 through 2005 (Plate 297). In 2006 and 2007 the rate of decline of the 15°C isopleths was similar in all three reservoirs (Plate 297). The decreasing rate in the decline of the 15°C isopleths at Garrison Reservoir, in comparison to Fort Peck and Oahe Reservoirs, in 2006 and 2007 is attributed to the short-term water management measures implemented at Garrison Dam to enhance coldwater habitat in Garrison Reservoir.

Table 5.23. Summary of general water quality conditions monitored at the Mainstem System reservoirs over the 5-year period 2003 through 2007. (Note: The 5-year period of 2003 through 2007 has been a period of severe drought in the western Untied States where the reservoirs are located.)

	Fort Peck	**Garrison**	**Oahe**	**Big Bend**	**Fort Randall**	**Gavins Point**
Maximum reservoir depth near the dam when pool elevation is at the top of Carryover Multiple Use Zone.	204 ft	168 ft	193 ft	75 ft	123 ft	48 ft
Minimum daily pool elevation recorded during the 5-year period 2003 through 2007.	2196.2 ft-msl	1805.8 ft-msl	1570.2 ft-msl	1419.4 ft-msl	1336.9 ft-msl	1204.9 ft-msl
Maximum reservoir depth near the dam at the minimum pool elevation recorded during the 5-year period 2003 through 2007.	166 ft	136 ft	155 ft	74 ft	110 ft	45 ft
Extent of hypolimnion formed during summer thermal stratification period	Large (Plate 11)	Large (Plate 66)	Large (Plate 134)	None (Plate 177)	Small (Plate 217)	Very Small (Plate 260)
Extent of dissolved oxygen degradation in the hypolimnion just prior to “fall turnover” of the reservoir	Minor (Plate 16)	Severe (Plate 73)	Minor (Plate 139)	None (Plate 178)	Moderate (Plate 222)	Severe (Plate 261)
Correlation of dam discharge water quality conditions to dam discharge rates during the summer	Low (Plates 30-45)	High (Plates 91-110)	Low (Plates 157-172)	Low (Plates 187-202)	High (Plates 238-253)	Low (Plates 277-292)
Lake trophic status[(1)]	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Eutrophic
Average TSI score[(2)]	45	47	46	49	47	57
Most prevalent phytoplankton group sampled[(3)]	Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta
Percent of samples where Cyanobacteria was the most prevalent phytoplankton group based on collected biovolume[(3)]	5%	0%	11%	11%	6%	6%
Percent of samples where Cyanobacteria were 10% or more of the collected phytoplankton biovolume[(3)]	35%	5%	32%	39%	11%	22%

(1) Based on near-dam water quality conditions in the reservoir.
(2) TSI = Trophic State Index (see text for explanation). Based on near-dam water quality conditions in the reservoir.
(3) Based on phytoplankton samples collected near the dam of each reservoir.

The rate of hypolimnetic warming of the three reservoirs appears to be related to the depth of water withdrawal from the reservoir. Garrison Reservoir has the deepest level of withdrawal (i.e., 2 feet above the reservoir bottom) and, except for 2006 and 2007, had the highest rate of warming. Oahe Reservoir has the shallowest level of withdrawal (i.e., 110 feet above the reservoir bottom) and had the lowest rate of warming. Fort Peck Reservoir has an intermediary level of withdrawal (i.e., 65 feet above the reservoir bottom) and had an intermediate rate of warming. In 2006 and 2007, the implemented short-term water quality management measures at Garrison Dam (i.e., plywood barriers on trash racks) resulted in an intermediary level of withdrawal, and in 2006 and 2007 the rate of hypolimnetic warming at Garrison Reservoir was similar to Fort Peck Reservoir. The near-bottom withdrawal of water from Garrison Reservoir, absent the trash-rack plywood barriers, undoubtedly causes mixing within the hypolimnion as water is discharged through the dam and evacuated from lower levels of the hypolimnion. This mixing induces the transfer of heat within the reservoir's hypolimnion and into it from the metalimnion. The elevation of water withdrawal from Oahe Reservoir is generally at or above the thermocline, especially during low pool levels, and extensive mixing and warming of the hypolimnion is not induced. Water withdrawn from Fort Peck Reservoir and from Garrison Reservoir with the trash-rack plywood barriers in place is from the upper depths of the hypolimnion, and some withdrawal-induced mixing and warming of the hypolimnion may take place.

5.8.3.2 Dissolved Oxygen

As was done for water temperature, near-bottom dissolved oxygen concentrations measured at the near-dam, deepwater monitoring sites in Fort Peck, Garrison, and Oahe Reservoirs during May through October of the 5-period 2003 through 2007 were plotted to compare the hypolimnetic dissolved oxygen conditions of the three reservoirs (Plate 298). For all 5 years, the near-bottom dissolved oxygen concentrations measured in Garrison Reservoir ended the summer period (i.e., just prior to fall turnover) with lower dissolved oxygen levels than the other two reservoirs (Plate 298). The hypolimnetic dissolved oxygen levels of all three reservoirs decreased every year over the summer period. The relative rates of dissolved oxygen degradation in the near-bottom water of the three reservoirs over the summer periods evaluated were somewhat consistent. The hypolimnetic dissolved oxygen degradation rates in Fort Peck and Oahe Reservoirs appeared similar and less those present in Garrison Reservoir (Plate 298).

5.8.3.3 Occurrence of Coldwater Habitat

The occurrence of coldwater habitat in Fort Peck, Garrison, and Oahe was compared based on the presence of optimal coldwater habitat conditions (i.e., temperature ≤15°C and dissolved oxygen ≥ 5 mg/l) measured at a near-dam, deepwater monitoring site in each reservoir. Plates 299, 300, and 301 plot the 15°C water temperature and 5 mg/l dissolved oxygen concentration isopleths measured in each reservoir during 2003 through 2007. The elevation of the power tunnel intakes into the dam (i.e., elevation of withdrawal from each reservoir) is shown as the dotted line (Plates 299 - 301). The occurrence of optimal coldwater habitat in each reservoir is represented by the area between the 15°C temperature and 5 mg/l dissolved oxygen isopleths. As shown in Plates 299 - 301, the occurrence of optimal coldwater habitat decreased in each reservoir during the summer; however, the decrease that occurred in Garrison Reservoir was greater. It appears that in 2005, 2006, and 2007 little optimal coldwater habitat was present in Garrison Reservoir in late summer just prior to fall turnover of the reservoir.

6 LOWER MISSOURI RIVER: GAVINS POINT DAM TO RULO, NE

6.1 CHANNEL CHARACTERISTICS AND TRIBUTARIES

The Missouri River between Gavins Point Dam (RM 811.1) and Rulo, NE (RM498.0) flows in an east-southeasterly to south-southeasterly direction. Major tributaries to the Missouri River below Gavins Point Dam, moving downstream, include: James River (South Dakota) at RM 800.8, Vermillion River (South Dakota) at RM 772.0, Big Sioux River (South Dakota and Iowa) at RM 734.0, Floyd River (Iowa) at RM 731.1, Little Sioux River (Iowa) at RM 669.2, Platte River (Nebraska) at RM 594.8, and Nishnabotna River (Iowa) at RM 542.0. Extensive bed degradation has occurred in the upper areas of this Missouri River reach because river sediment is captured above Gavins Point Dam. Another factor is the substantial Missouri River channel shortening that occurred as part of the downstream Missouri River Bank Stabilization and Navigation Project. Gradual armoring of the riverbed has reduced the rate of channel degradation. Since 1965, approximately 10 feet of stage reduction has occurred for a discharge of 30,000 cfs in the Sioux City, IA area. During this period channel degradation of the Missouri River downstream in the Omaha, NE (RM 615.9) area has been non-existent. This reach of the Missouri River can be separated into three distinct sub reaches: the Missouri River National Recreational River, Kensler's Bend, and the Missouri River Navigation Channel reaches.

6.1.1 MISSOURI RIVER NATIONAL RECREATION RIVER REACH

The 59-mile reach of the Missouri River downstream of Gavins Point Dam starting at RM 811.0 down to Ponca, NE (RM 752.0) has been designated a National Recreational River under the Federal Wild and Scenic Rivers Act. This reach of the river has not been channelized by construction of dikes and revetments, and has a meandering channel with many chutes, backwater marshes, sandbars, islands, and variable current velocities. Snags and deep pools are also common. Although this portion of the river includes some bank stabilization structures, the river remains fairly wide. Bank erosion rates since the closure of Gavins Point Dam in 1956 have averaged 132 acres per year between Gavins Point Dam and Ponca, compared to a pre-dam rate of 202 acres per year. The rate of erosion had been declining since 1975 and then dramatically increased during the high flow years of 1995 through 1997.

6.1.2 KENSLER'S BEND REACH

The Kensler's Bend reach of the Missouri River extends from Ponca, Nebraska (RM 752.0) to above Sioux City, IA (RM 735.0). The Missouri River banks have been stabilized with dikes and revetments through this reach, but it has not been channelized.

6.1.3 MISSOURI RIVER NAVIGATION CHANNEL REACH

The reach of the Missouri River from the end of the Kensler's Bend reach (RM 735.0) to Rulo, NE (RM 498.0) has been modified over its entire length by an intricate system of dikes and revetments designed to provide a continuous navigation channel without the use of locks and dams. This reach is managed by the Corps under the Missouri River Bank Stabilization and Navigation Project. In addition to the primary authorization to maintain a navigation channel (9 ft deep by 300 ft wide) downstream from Sioux City, IA to the mouth of the Missouri River, there are authorizations to stabilize the river's banks.

6.2 FLOW REGULATION

Releases from Gavins Point Dam follow the same pattern as those from Fort Randall Dam because there is little active storage in Gavins Point Reservoir. Releases from both dams are based on the amount of water in Mainstem System storage, which governs how much water will be released to meet service demands in the portion of the lower Missouri River from Sioux City, IA to St. Louis, MO. Constraints for flood control, threatened and endangered bird nesting, and fish spawning also are factors governing releases. Releases from Gavins Point Dam generally fall into three categories: navigation, flood evacuation, and nonnavigation releases.

6.2.1 MAINSTEM SYSTEM SERVICE LEVEL

To facilitate appropriate application of multipurpose regulation criteria to the Mainstem System, a numeric "service level" has been adopted since the Mainstem System was first filled in 1967. Quantitatively, a full service level approximates the water release rate necessary to achieve a normal 8-month navigation season with average downstream tributary flow contributions. For "full-service" and "minimum service" levels, the numeric service level values are, 35,000 cfs (cubic feet per second) and 29,000 cfs, respectively. This service level is used for selection of appropriate flow target values at previously established downstream control locations on the Missouri River. There are four flow target locations selected below Gavins Point Dam to assure that the Missouri River has adequate water available for the entire downstream reach to achieve regulation objectives. The four flow target locations and their flow target discharge deviation from service levels are: Sioux City (-4,000 cfs); Omaha (-4,000 cfs); Nebraska City (+2,000 cfs); and Kansas City (+6,000 cfs). A full-service level of 35,0000 cfs results in target discharges of 31,000 cfs at Sioux City and Omaha; 37,000 cfs at Nebraska City; and 41,000 cfs at Kansas City. Similarly, a minimum-service level of 29,000 cfs results in target values of 6,000 cfs less than the full-service levels at the four target locations. The relation of service levels to the volume of water in Mainstem System storage is as follows:

Date	Water in Mainstem System Storage (MAF)	Service Level (cfs)
March 15	54.5 or more*	35,000 (full-service)
March 15	31.0 to 49.0*	29,000 (minimum-service)
March 15	31.0 or less	No Service
July 1	57.0 or more*	35,000 (full-service)
July 1	50.5 or less*	29,000 (minimum-service)
* Straight-line interpolation defines intermediate service levels between full and minimum service.		

The length of the navigation season is determined by the volume of water in storage as follows:

Date	Water in Mainstem System Storage (MAF)	Season Closure Date at Mouth of Missouri River
March 15	Less than 31.0	No season
July 1	51.5 or more*	December 1 (8-month season)
July 1	41.0 to 46.8*	November 1 (7-month season)
July 1	36.5 or less*	October 1 (6-month season)
* Straight-line interpolation defines intermediate closure date between given values.		

6.2.2 HISTORIC FLOW RELEASES

In the navigation season, which generally runs from April 1 through November 30, releases from Gavins Point Dam are generally 25,000 to 35,000 cfs. In the winter, releases are in the 10,000- to 20,000-

cfs range. In wet years with above-normal upstream inflows, releases are higher to evacuate flood control storage space in upstream reservoirs. Maximum winter releases are generally kept below 24,000 cfs to minimize downstream flooding problems caused by ice jams in the lower river. During the 1987 to 1993 and the 2000 to present droughts, nonnavigation releases were generally in the 8,000- to 9,000- fs range immediately following the end and preceding the start of the navigation season. During cold weather, releases were increased up to 15,000 cfs, but generally averaged 12,000 cfs over the 3-month winter period from December through February.

6.2.3 FLOW RELEASES FOR WATER QUALITY MANAGEMENT

Generally, Mainstem System release levels necessary to meet downstream water supply purposes exceed the minimum release levels necessary to meet minimum downstream water quality requirements. Tentative flow requirements for satisfactory water quality were first established by the U.S. Public Health Service and presented in the 1951 Missouri Basin Inter-Agency Committee Report on Adequacy of Flows in the Missouri River. These requirements were used in Mainstem System regulation until revisions were made in 1969 by the Federal Water Pollution Control Administration. The Missouri River minimum daily flow requirements for water quality (i.e., dissolved oxygen) that are given below were initially established by the Federal Water Pollution Control Administration in 1969. They were reaffirmed by the U.S. Environmental Protection Agency in 1974 after consideration of: 1) the current status of PL 92-500 programs for managing both point and non-point sources discharging into the river, and 2) the satisfactory adherence to the dissolved-oxygen concentration of 5.0 mg/l. The minimum daily flow requirements listed below are used for Mainstem System regulation purposes.

Location	Dec, Jan, Feb	Mar, Apr	May	Jun, Jul, Aug, Sep	Oct, Nov
Sioux City, IA	1,800 cfs	1,370 cfs	1,800 cfs	3,000 cfs	1,350 cfs
Omaha, NE	4,500 cfs	3,375 cfs	4,500 cfs	7,500 cfs	3,375 cfs
Kansas City, MO	5,400 cfs	4,050 cfs	5,400 cfs	9,000 cfs	4,050 cfs

Low flows in the Missouri River downstream from Gavins Point Dam may affect the ability of powerplants on this reach to meet National Pollutant Discharge Elimination System (NPDES) permit thermal limits for discharging cooling water back into the Missouri River.

6.2.4 FLOW TRAVEL TIMES

For purposes of scheduling releases, approximate open water travel times from Gavins Point Dam are 1.5 days to Sioux City; 3 days to Omaha; 3.5 days to Nebraska City; 5.5 days to Kansas City; and 10 days to the mouth of the Missouri River near St. Louis.

6.3 HISTORIC FLOW CONDITIONS (1967 TO 2007)

Historic flow conditions for the period 1967 through 2007 were determined from Corps and USGS gaging sites along the Missouri River from Gavins Point Dam to Rulo, NE. The gaging sites include: Gavins Point Dam; Omaha; Nebraska City; and Rulo. Box plots showing the distribution of the mean daily flows measured over the 40-year period are shown in Figure 6.1.

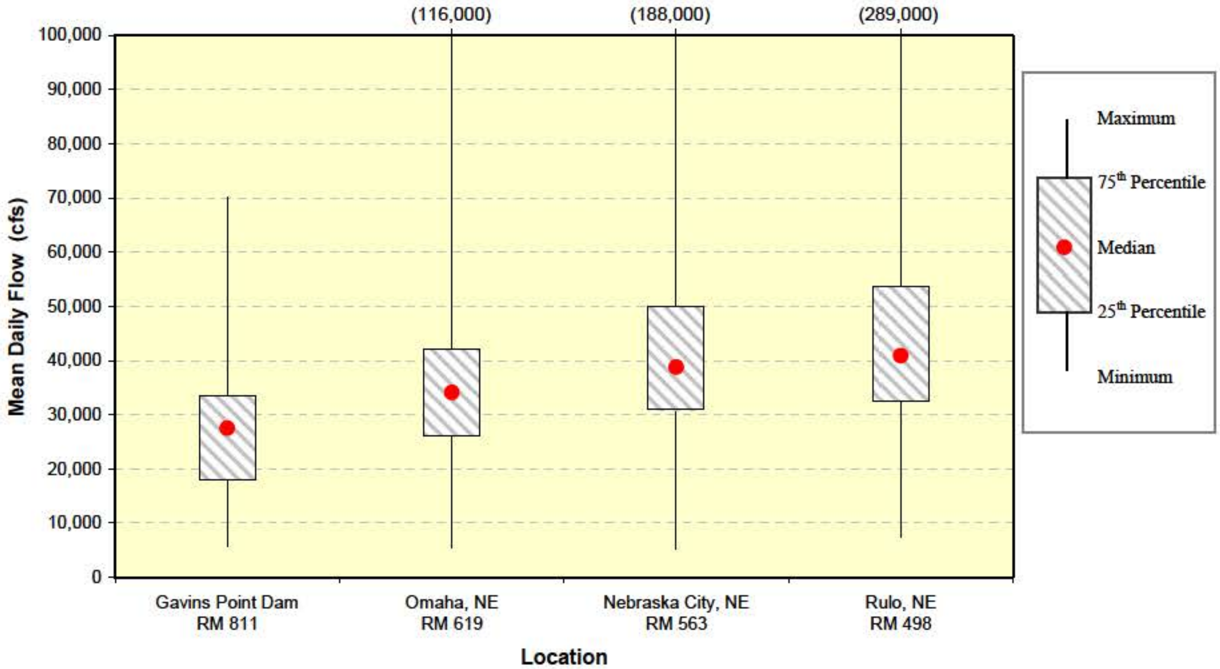

Figure 6.1. Distribution of mean daily flows recorded at gaging sites on the Missouri River at Gavins Point Dam, Omaha, NE, Nebraska City, NE, and Rulo, NE during the 41-year period of 1967 through 2007.

6.4 NATIONAL RECREATION RIVER DESIGNATION PURSUANT TO THE FEDERAL WILD AND SCENIC RIVERS ACT

The 59-mile "natural-channel" reach from Gavins Point Dam to Ponca State Park, NE has been designated as a National Recreational River under the Federal Wild and Scenic Rivers Act (WSRA). The National Park Service (NPS) manages the reach under the WSRA. The justification that supported that this reach of the Missouri River be protected as a recreational river identified its outstanding remarkable recreational, fish and wildlife, aesthetic, historical, and cultural values. Under the WSRA, the U.S. Department of Interior (i.e., NPS) is mandated to administer this reach in a manner that will protect and enhance these values for the benefit and enjoyment of present and future generations.

6.5 STATE DESIGNATIONS AND LISTINGS PURSUANT TO THE FEDERAL CLEAN WATER ACT

Pursuant to the Federal Clean Water Act (CWA), the States of South Dakota, Nebraska, Iowa, and Missouri have designated water quality-dependent beneficial uses, in their State water quality standards, for appropriate reaches of the Missouri River downstream of Gavins Point Dam. South Dakota has designated the following uses for all of the Missouri River within the state downstream of Gavins Point Dam: primary contact recreation, warmwater fishery, drinking water supply, and industrial water supply. Nebraska has designated the following uses to the entire length of the Missouri River in Nebraska: primary contact recreation, warmwater aquatic life, agricultural water supply, and aesthetics. It has designated the use of drinking water supply to the river below the confluence of the Niobrara River, and industrial water supply to the river below the confluence of the Big Sioux River. Nebraska has also

designated the reach between Gavins Point Dam and Ponca State Park as Outstanding State Resource Waters for "Tier 3" protection under the State's water quality standard's antidegradation policy. Iowa has designated the following uses to all of the Missouri River in the state: primary contact recreation, warmwater fishery, and high quality state resource water. It has also designated the use of drinking water supply to the river in the area of Council Bluffs, IA. Missouri has designated the following uses to the river: primary contact recreation, warmwater fishery, drinking water supply, agricultural water supply, and industrial water supply. The States of Nebraska, Iowa, and Missouri have listed the Missouri River on their State's Section 303(d) list of impaired waters. The pollutant/stressors identified are pathogens, siltation, habitat loss, Dieldrin, PCBs, and arsenic. The source of siltation and habitat loss is identified as hydrologic modifications and channelization. The source of Dieldrin and PCBs is residual contamination, as both substances have been banned since the 1980's. The identified sources for the pathogens are municipal point sources, agriculture, and urban runoff.

6.6 EXISTING WATER QUALITY CONDITIONS (2002 THROUGH 2007)

The Omaha District, in cooperation with the Nebraska Department of Environmental Quality (NDEQ), conducted fixed-station water quality monitoring at seven sites along the Missouri River from Gavins Point Dam to Rulo, NE during the 5-year period of 2003 through 2007. The location of the seven sites were Gavins Point Dam tailwaters (site GPTRRTW1); near Maskell, NE (site MORRR0774); near Ponca, NE (site MORRR0753); at Decatur, NE (site MORRR0691); at Omaha, NE (site MORRR0619); at Nebraska City, NE (site MORRR0563); and at Rulo, NE (site MORRR0498) (Figure 6.2).

6.6.1 STATISTICAL SUMMARY AND COMPARISON TO APPLICABLE WATER QUALITY STANDARDS CRITERIA

During the 5-year period, water quality samples at the seven sites were collected monthly from October through March and biweekly from April through September. Plates 302 through 308 summarize the water quality conditions that were monitored at the seven sites. A review of these results indicated no major water quality concerns.

6.6.2 LONGITUDINAL VARIATION IN WATER QUALITY

The distributions of selected parameters measured over the 5-year period were depicted as box plots at each of the seven monitored locations. The parameters plotted include water temperature, dissolved oxygen, pH, specific conductance, chloride, turbidity, total suspended solids, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, total ammonia nitrogen, nitrate-nitrite nitrogen, total phosphorus, atrazine, and metolachlor (Plate 309). For comparison purposes, box plots for the individual parameters measured at each of the seven sites are arranged relative to their respective location in an upstream to downstream order (i.e., GPTRRTW1 = RM811, MORRR0774 = RM774, MORRR0753 = RM753, MORR0691 = RM691, MORR0619 = RM619, MORR0563 = RM563, and MORR0498 = RM498). Four longitudinal trends were categorized based on the constructed longitudinal box plots: 1) parameter exhibits no observable longitudinal trend, 2) parameter slightly decreases in a downstream direction, 3) parameter slightly increases in a downstream direction, and 4) parameter greatly increases in a downstream direction. Parameters that exhibited no observable longitudinal trend included pH, specific conductance, and total ammonia (Plate 309). Dissolved oxygen is the only parameter that slightly decreased in a downstream direction (Plate 309). Parameters that slightly increased in a downstream direction included water temperature, chloride, chemical oxygen demand, total organic carbon, total Kjeldahl nitrogen, atrazine, and metolachlor (Plate 309 and Figure 6.3). Parameters that greatly increased in a downstream direction included turbidity, total suspended solids, nitrate-nitrite nitrogen, and total phosphorus (Plate 309).

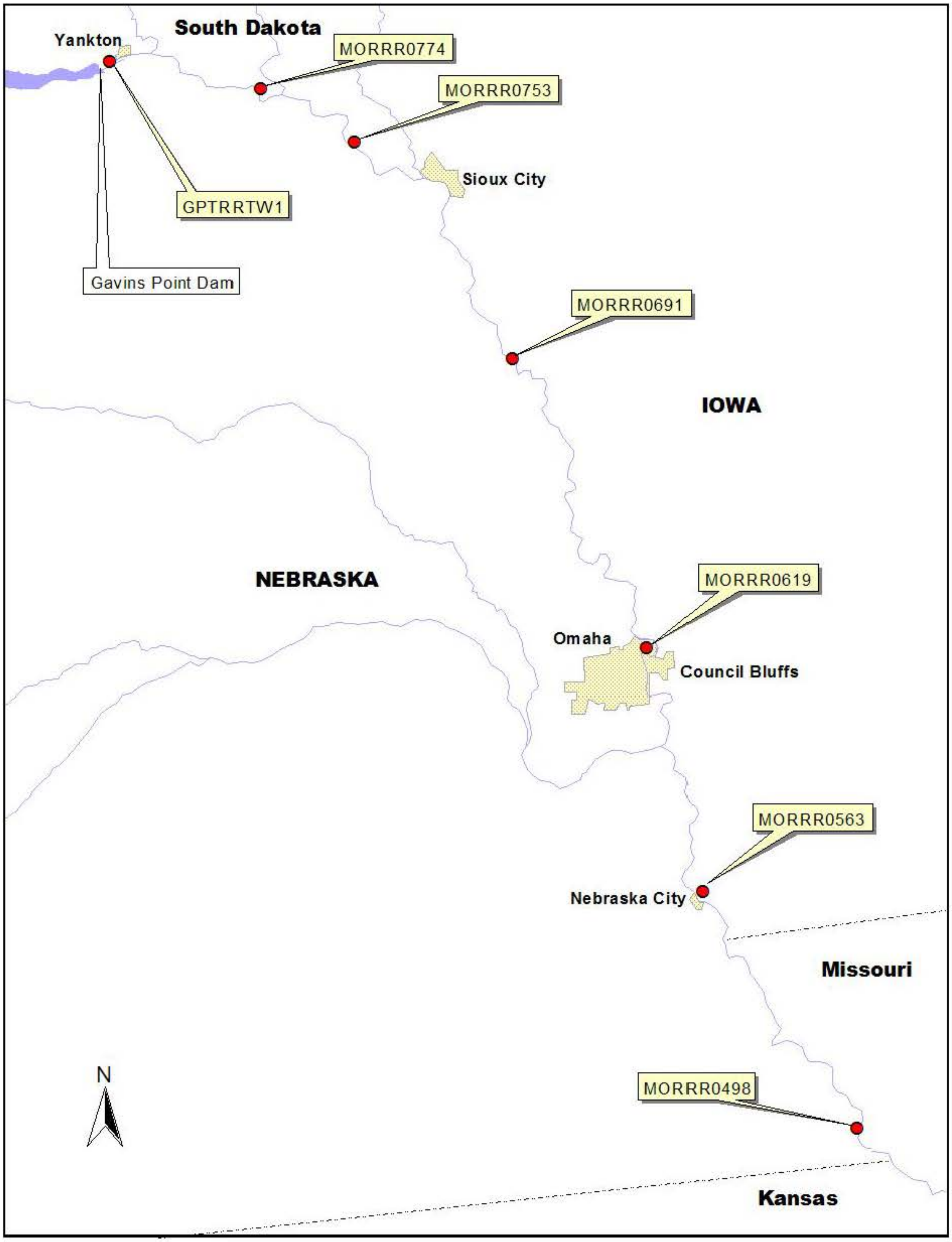

Figure 6.2. Locations of water quality monitoring sites along the Missouri River from Gavins Point Dam to Rulo, NE.

6.7 NUTRIENT FLUX CONDITIONS

Nutrient flux rates along the lower Missouri River from the Gavins Point Dam tailwaters to Rulo, NE were calculated based on monitoring data collected at the seven monitoring locations over the 5-year period 2003 through 2007 (Tables 6.1 - 6.7).

Table 6.1. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at the Gavins Point tailwaters (i.e., site GTPRRTW1) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	81	82	81	81	80
Mean	0.069	0.281	0.033	0.064	1.921
Median	0.047	0.221	n.d.	0.040	2.131
Minimum	n.d.	n.d.	n.d.	n.d.	0.713
Maximum	0.341	1.937	0.600	0.623	4.638

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 20,405 cfs, median = 21,993 cfs, minimum = 8,000 cfs, and maximum = 30,963 cfs.

Table 6.2. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River near Maskell, NE (i.e., site MORRR0774) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	80	81	81	80	79
Mean	0.083	0.342	0.058	0.048	2.102
Median	0.052	0.280	0.037	0.035	2.312
Minimum	n.d.	n.d.	n.d.	n.d.	0.572
Maximum	0.509	1.865	0.372	0.256	3.684

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 21,843 cfs, median = 23,866 cfs, minimum = 9,161 cfs, and maximum = 31,082 cfs.

Table 6.3. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River near Ponca, NE (i.e., site MORRR0753) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	77	78	78	77	76
Mean	0.080	0.427	0.054	0.073	2.281
Median	0.035	0.337	0.009	0.044	2.400
Minimum	n.d.	n.d.	n.d.	n.d.	0.757
Maximum	0.377	1.869	0.474	0.518	4.014

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 22,023 cfs, median = 23,950 cfs, minimum = 9,247 cfs, and maximum = 31,661 cfs.

Table 6.4. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Decatur, NE (i.e., site MORRR0691) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	83	84	83	83	81
Mean	0.116	0.683	0.678	0.146	2.850
Median	0.060	0.500	0.423	0.084	2.783
Minimum	n.d.	n.d.	n.d.	n.d.	0.714
Maximum	0.515	4.611	3.474	1.012	10.859

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 25,808 cfs, median = 27,050 cfs, minimum = 11,500 cfs, and maximum = 42,400 cfs.

Table 6.5. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Omaha, NE (i.e., site MORRR0619) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	84	85	84	84	83
Mean	0.139	0.930	1.317	0.265	3.276
Median	0.066	0.635	0.875	0.122	2.926
Minimum	n.d.	0.083	n.d.	0.024	1.038
Maximum	0.699	5.033	6.304	2.573	9.435

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 28,421 cfs, median = 29,000 cfs, minimum = 13,300 cfs, and maximum = 50,600 cfs.

Table 6.6. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Nebraska City, NE (i.e., site MORRR0563) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	85	86	85	85	84
Mean	0.176	1.444	1.565	0.457	4.078
Median	0.098	0.874	1.083	0.212	3.650
Minimum	n.d.	0.085	0.041	0.065	1.960
Maximum	0.942	11.394	9.718	3.892	11.600

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 34,132 cfs, median = 33,675 cfs, minimum = 16,700 cfs, and maximum = 85,800 cfs.

Table 6.7. Summary of nutrient flux rates (kg/sec) calculated for the Missouri River at Rulo, NE (i.e., site MORRR0498) over the 5-year period 2003 through 2007.

Statistic	Total Ammonia N (kg/sec)	Total Kjeldahl N (kg/sec)	Total NO_3-NO_2 N (kg/sec)	Total Phosphorus (kg/sec)	Total Organic Carbon (kg/sec)
No. of Obs.	84	85	84	84	83
Mean	0.181	1.392	1.665	0.421	3.915
Median	0.078	0.936	1.500	0.258	3.313
Minimum	n.d.	0.275	0.030	0.059	0.968
Maximum	1.132	11.116	4.300	3.500	10.910

Note1: Non-detect values set to 0 for flux calculations.
Note2: Statistics of Missouri River flows used for flux calculations were: mean = 35,122 cfs, median = 33,800 cfs, minimum = 17,500 cfs, and maximum = 72,700 cfs.

6.8 USGS WATER QUALITY MONITORING IN 2007

During 2007, the USGS conducted "real-time" water quality monitoring at several sites along the lower Missouri River. Monitoring sites on the Missouri River from Gavins Point Dam to near Rulo, Nebraska included: Yankton, SD (station 06467500); Ponca, NE (station 06479097); Sioux City, IA (station 06486000); Decatur, NE (station 06601200); Omaha, NE (station 06610000); Nebraska City, NE (Station 06807000); and St. Joseph, MO (station 06818000). "Real-time" water quality parameters that were monitored included water temperature, dissolved oxygen, pH, specific conductance, and turbidity. These water quality data are available on the following USGS web site: *http://ne.water.usgs.gov/missouririverwq/index.html.*

6.9 WATER TEMPERATURES MONITORED ALONG THE LOWER MISSOURI RIVER IN 2007

Mean daily water temperatures were calculated from data recorded in 2007 at monitoring locations along the lower Missouri River. Figure 6.3 plots 2007 mean daily water temperatures for the Missouri River at Gavins Point Dam; Ponca, NE; Sioux City, IA; Decatur, NE; Omaha, NE; and St. Joseph, MO.

6.10 CURRENT TOTAL NITROGEN AND TOTAL PHOSPHORUS LOADINGS ALONG THE MISSOURI RIVER IN THE OMAHA DISTRICT

Loadings for total nitrogen and total phosphorus were estimated for selected locations along the Missouri River in the Omaha District based on monitoring conducted during the 5-year period of 2003 through 2007. Daily loadings were calculated from instantaneous flux rates measured for total nitrogen (i.e., total Kjeldahl nitrogen plus nitrate-nitrite nitrogen) and total phosphorus determined for monitored sites. Daily loadings were estimated for the Missouri River at the following 16 sites: 1) near Landusky, MT [RM 1921]; 2) at Fort Peck Dam [RM 1771]; 3) Near Williston, ND [RM 1553]; 4) at Garrison Dam [RM 1389]; 5) at Bismarck, ND [RM 1315]; 6) at Oahe Dam [RM 1072]; 7) at Big Bend Dam [RM 986]; 8) at Fort Randall Dam [RM 879]; 9) near Verdel, NE [RM 851]; 10) at Gavins Point Dam [RM 811]; 11) near Maskell, NE [RM 774]; 12) near Ponca, NE [RM 753]; 13) at Decatur, NE [RM 691]; 14) at Omaha, NE [RM 619]; 15) at Nebraska City, NE [RM 563]; and 16) at Rulo, NE [RM 498]. Figure 6.4 plots the estimated mean daily loads in tons per day at the 16 sites.

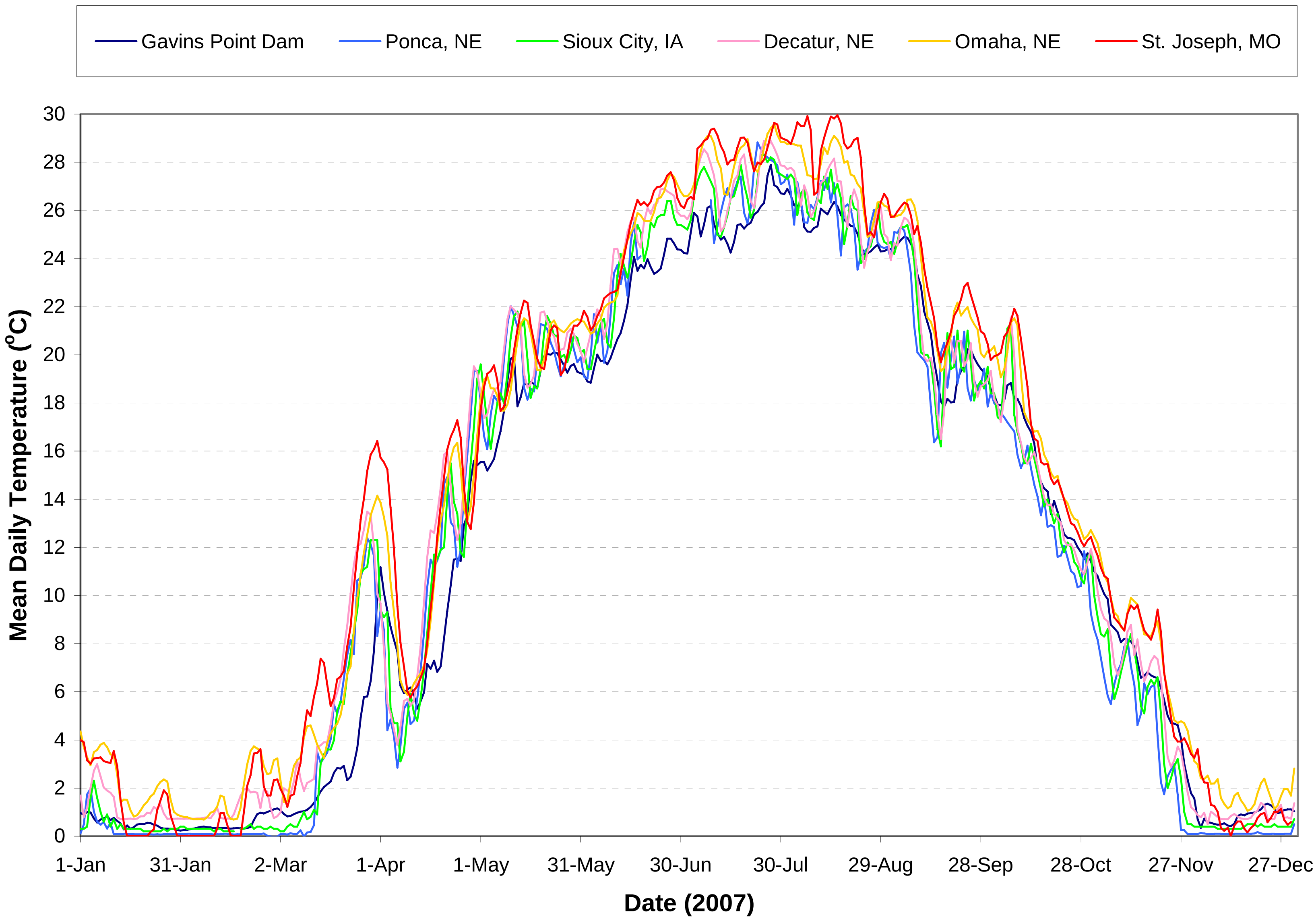

Figure 6.3. Mean daily water temperatures calculated for the lower Missouri River during 2007 at Gavins Point Dam;Ponca, NE; Sioux City, IA; Decatur, NE; Omaha, NE; and St. Joseph, MO.

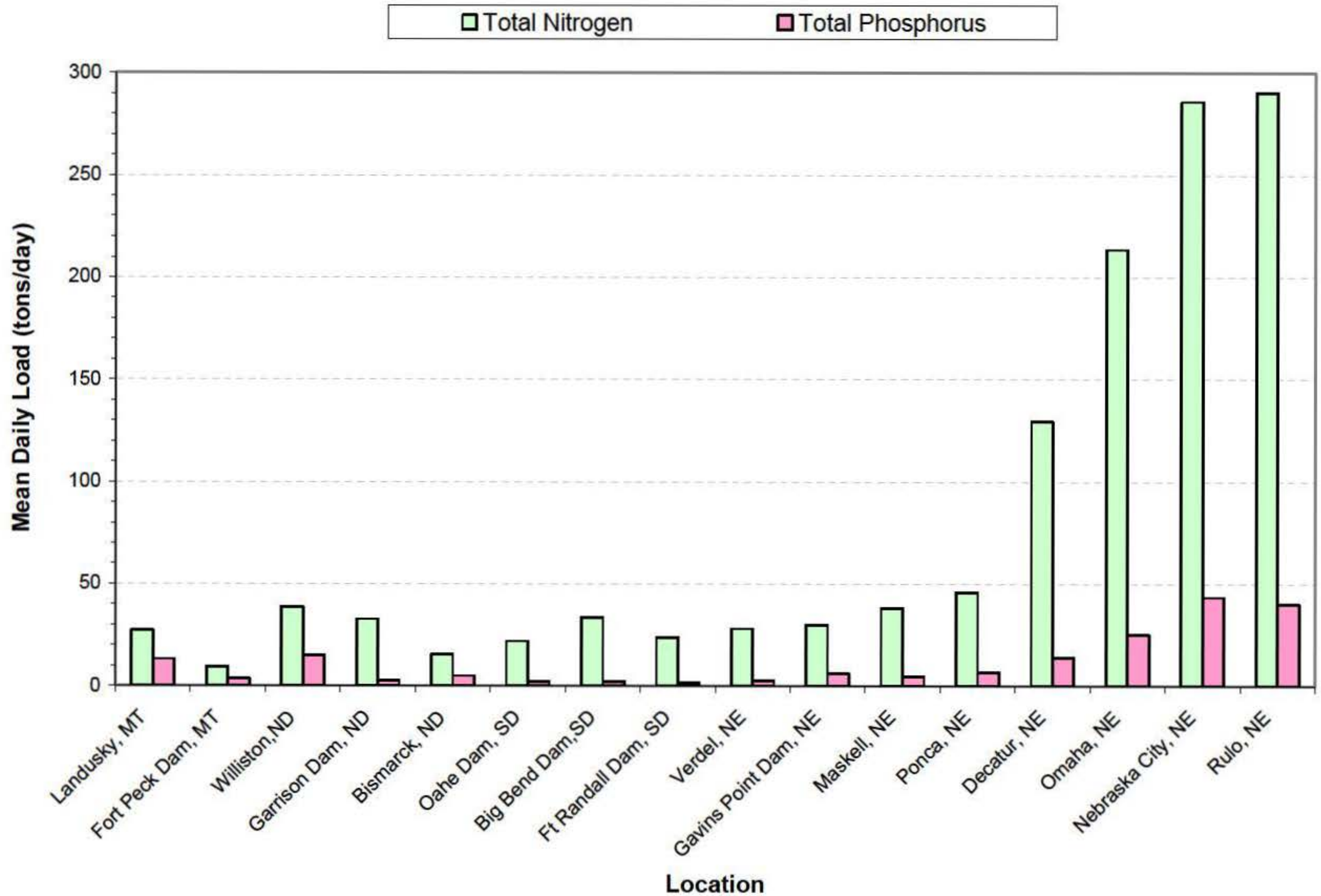

Figure 6.4. Estimated total nitrogen and total phosphorus loads for the Missouri River at selected locations in the Omaha District based on monitoring conducted during the 5-year period 2003 through 2007.

7 MAINSTEM ANCILLARY LAKES

7.1 LAKE AUDUBON

7.1.1 BACKGROUND INFORMATION

7.1.1.1 Lake Description

Lake Audubon is a sub-impoundment of Garrison Reservoir that is impounded by the Snake Creek Dam. Lake Audubon is located 12 miles northeast of Garrison Dam near the town of Garrison, ND. The Snake Creek Dam was constructed in 1954 with the primary purpose of relocating transportation and utility services inundated by the creation of Garrison Reservoir. A future purpose of Lake Audubon was to facilitate diversion for the purposes of irrigation, water supply, and pollution abatement. Maintenance of a stable sub-impoundment in the Snake River arm of Garrison Reservoir for wildlife and recreational development was defined as a desirable feature. The Snake River Dam has a crest elevation of 1865 ft-msl, and Lake Audubon pool levels are normally kept at about 1847 ft-msl in the summer and 1845 ft-msl in the winter. At pool elevation 1847 ft-msl, Lake Audubon has a surface area of approximately 18,780 acres. The lake is operated in cooperation with the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and the North Dakota Game and Fish Department.

7.1.1.2 Water Quality Standards and Section 303(d) Listings

Pursuant to the Federal CWA, the State of North Dakota has designated Lake Audubon as a Class 2 lake. As such, the lake is to be suitable for the propagation and maintenance of a cool-water fishery (i.e., northern pike and walleye) and associated biota; swimming, boating, and other water recreation; irrigation; stock watering; wildlife; and for municipal or domestic use after appropriate treatment. The State of North Dakota has not placed the lake on the State's Section 303(d) list of impaired waters, but has issued a statewide fish consumption advisory, which applies to Lake Audubon, due to mercury concerns.

7.1.1.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at Lake Audubon since 1980. Figure 7.1 show the location at Lake Audubon that has been monitored for water quality during the past 6 years. The near-dam site was monitored in 2002 and 2006.

7.1.2 EXISTING WATER QUALITY CONDITIONS (2002 THROUGH 2007)

7.1.2.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 310 summarizes the water quality conditions that were monitored in Lake Audubon at the near-dam, deepwater ambient monitoring site (i.e., site AUDLKND1) during 2002 and 2006. A review of these results indicated no water quality concerns.

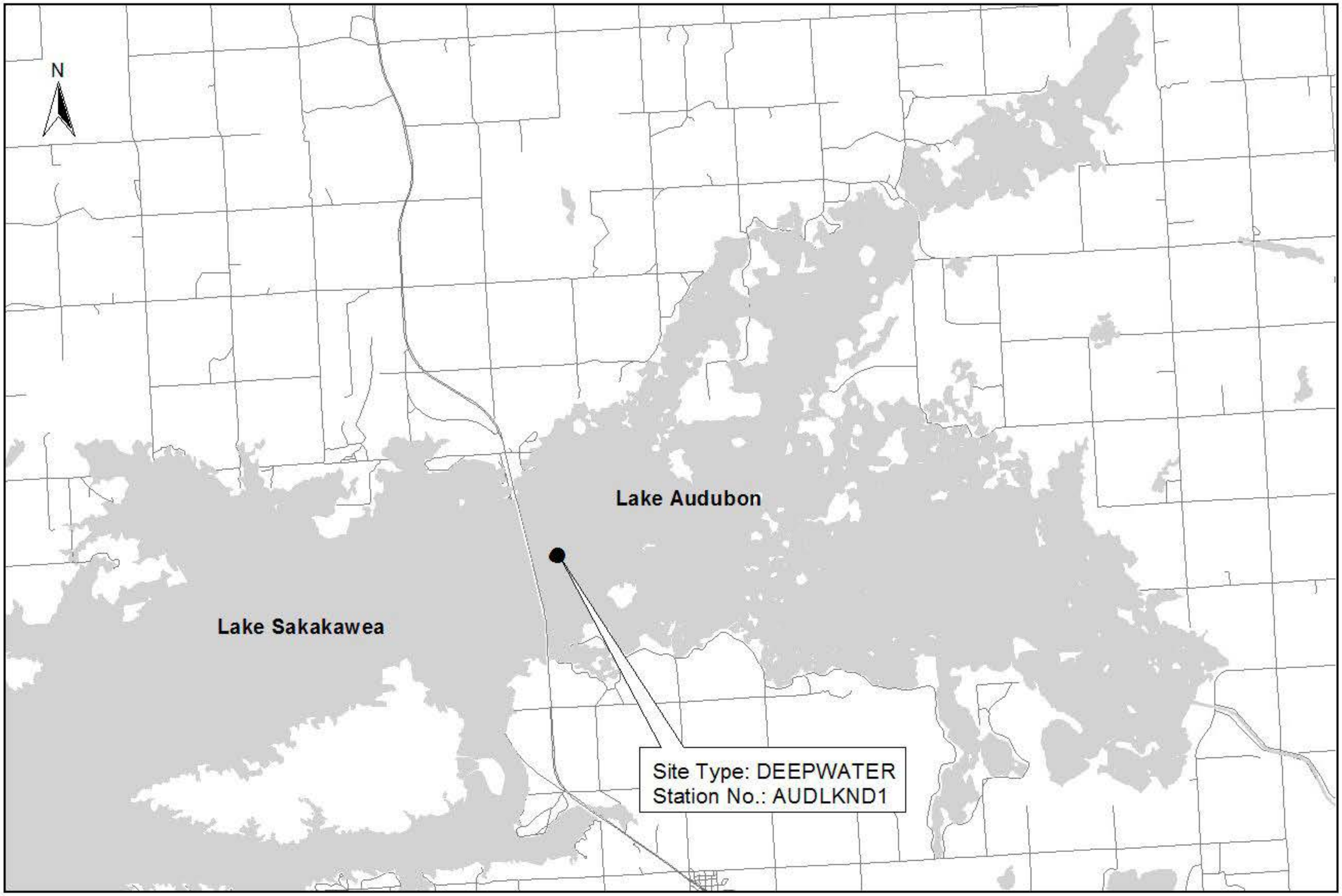

Figure 7.1. Location of water quality monitoring site at Lake Audubon.

7.1.2.2 Summer Thermal Stratification

Existing summer thermal stratification was assessed for Lake Audubon, based on monitoring results obtained at the near-dam, deepwater ambient monitoring site (i.e., site AUDLKND1) during 2002 and 2006. Temperature depth profiles were constructed from water quality data collected during the summer months (Plate 311). It appears a temperature-depth gradient occasionally occurs in Lake Audubon in the near-dam lacustrine area during the summer (Plate 311). When temperature stratification occurred, a thermocline was present near the lake bottom at about 13 meters depth. This indicates the reservoir is probably polymixic. During periods of calm weather in the summer, Lake Audubon likely develops a slight thermal stratification. The thermal stratification seemingly breaks down under windier conditions, given the shallow depth of the reservoir (i.e., 16 meters), allowing the reservoir to mix throughout the water column.

7.1.2.3 Summer Dissolved Oxygen Conditions

Existing summer dissolved oxygen conditions were assessed for Lake Audubon based on monitoring results obtained at the near-dam, deepwater ambient monitoring site during 2002 and 2006. Dissolved oxygen depth profiles were constructed from water quality data collected during the summer months (Plate 312). The measured summer dissolved oxygen-depth profiles exhibited some variability with depth. On occasions, low dissolved oxygen concentrations were measured near the reservoir bottom. The variability of the summer dissolved oxygen-depth profiles is attributed to the probable polymictic nature of the lake. When thermal stratification of the reservoir develops in the summer, significant dissolved oxygen degradation occurs in the near-bottom area of the hypolimnion. The lowest dissolved oxygen concentration measured was 1.7 mg/l, and was measured near the reservoir bottom on July 25, 2006.

7.1.2.4 Lake Trophic Status

Trophic State Index (TSI) values for Lake Audubon were calculated from monitoring data collected during 2002 and 2006 at the near-dam, ambient monitoring site (i.e., site AUDLKND1). Table 7.1 summaries the TSI values calculated for the lake. The TSI values indicate that the near-dam lacustrine area of Lake Audubon is in a mesotrophic to moderately eutrophic state.

Table 7.1. Summary of Trophic State Index (TSI) values calculated for Lake Audubon for 2002 and 2006.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	7	50	52	43	57
TSI(TP)	7	54	52	41	76
TSI(Chl)	4	44	43	40	50
TSI(Avg)	7	49	48	42	57

* TSI(SD), TSI(TP), and TSI(Chl) are TSI index values based, respectively, on Secchi depth, total phosphorus, and chlorophyll *a* measurements. TSI(Avg) is the average of TSI values irregardless of the parameters available to calculate the average.

Note: See Section 4.1.4 for discussion of TSI calculation.

7.1.3 WATER QUALITY TRENDS (1980 THROUGH 2006)

Water quality trends over the period of 1980 through 2006 were determined for Lake Audubon for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the lake during the months of May through October at the near-dam monitoring site (i.e., site AUDLKND1). Plate 313 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. For the assessment period, it appears that Lake Audubon exhibited decreasing concentrations of total phosphorus and chlorophyll *a* and no noticeable change in transparency (i.e. Secchi depth). Over the 27-year period, the lake has generally remained in a moderately eutrophic state with calculated TSI values showing a slight decreasing trend (Plate 313).

7.2 LAKE POCASSE

7.2.1 BACKGROUND INFORMATION

7.2.1.1 Lake Description

Lake Pocasse is a sub-impoundment of Oahe Reservoir on Spring Creek that is impounded by the Spring Creek Dam. Lake Pocasse is located in Campbell County, SD, near the town of Pollock. The Spring Creek Dam was built in lieu of a road relocation with a bridge spanning Spring Creek. The purpose of the sub-impoundment was to provide lake and marsh habitat for fish and wildlife management on the Spring Creek bottoms within the Oahe Reservoir pool area. In October 1962, a National Wildlife Refuge was established in the Spring Creek Bottoms, which includes Lake Pocasse. The U.S. Fish and Wildlife Service is responsible for the maintenance and management of wildlife habitat at Lake Pocasse. At the top of the multi-purpose pool (elevation 1614 ft-msl), Lake Pocasse has a surface area of approximately 1,545 acres and a volume of 7,100 acre-feet

7.2.1.2 Water Quality Standards and Section 303(d) Listings

The State of South Dakota has designated the following water quality-dependent beneficial uses for Lake Pocasse in the State's water quality standards: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, fish and wildlife propagation, and stock watering. The State of South Dakota has placed Lake Pocasse on the State's Section 303(d) list of impaired waters as a category 5 waterbody. The identified impaired use is warmwater permanent fish life, with the impairment attributable to nonpoint source pollution. The State has not issued a fish consumption advisory for the lake.

7.2.1.3 Ambient Water Quality Monitoring

The District has not monitored water quality conditions at Lake Pocasse historically or during the period of 2003 through 2007.

7.3 LAKE YANKTON

7.3.1 BACKGROUND INFORMATION

7.3.1.1 Lake Description

Lake Yankton is an "oxbow" lake of the Missouri River that straddles the Nebraska and South Dakota border, just below Gavins Point Dam. The lake was formed when the Gavins Point Dam embankment and the training dike downstream of the dam's outlet were constructed and cutoff a portion of the Missouri River channel. Lake Yankton has a surface area of approximately 250 acres.

7.3.1.2 Water Quality Standards and Section 303(d) Listings

Pursuant to the Federal Clean Water Act, the State of South Dakota has designated the following water quality-dependent beneficial uses for Lake Yankton: recreation (i.e., immersion and limited-contact), warmwater permanent fish life propagation, fish and wildlife propagation, and stock watering. The State of Nebraska has designated the following beneficial uses to Lake Yankton: primary contact recreation, Class I warmwater aquatic life, agricultural water supply, and aesthetics. The uses designated by the States of South Dakota and Nebraska to Lake Yankton are consistent with each other. Neither of the two States has placed Lake Yankton on the State's Section 303(d) list of impaired waters, or has issued fish consumption advisories for the lake.

7.3.1.3 Ambient Water Quality Monitoring

The District has monitored water quality conditions at Lake Yankton since 1982. Figure 7.2 shows the location at Lake Yankton that has been monitored for water quality during the past 6 years. This deepwater site was monitored in 2002 and 2006.

7.3.2 EXISTING WATER QUALITY CONDITIONS (2002 THROUGH 2006)

7.3.2.1 Statistical Summary and Comparison to Applicable Water Quality Standards Criteria

Plate 314 summarizes the water quality conditions that were monitored in Lake Yankton at the deepwater ambient monitoring site (i.e., site YAKLKND1) during 2002 and 2006. Based on the criteria for the protection of warmwater aquatic life, 36% of the observations did not meet the dissolved oxygen criterion. The dissolved oxygen measurements that were below the 5.0 mg/l criterion occurred near the lake bottom in the hypolimnion during the summer on occasions when the lake was thermally stratified. Nebraska's dissolved oxygen criteria are not applicable to the hypolimnion when lakes are thermally stratified. The pesticides atrazine and chlorpyrifos were detected on one occasion at levels above State water quality standards criteria.

7.3.2.2 Near-Dam Temperature Depth-Profile Plots

Existing summer thermal stratification was assessed for Lake Yankton, based on monitoring results obtained at the deepwater ambient monitoring site (i.e., site YAKLKND1) during 2002 and 2006. Temperature depth profiles were constructed from water quality data collected during the summer months (Plate 315). Summer thermal stratification appears to be present in Lake Yankton, with water temperatures near the lake bottom being up to 10°C cooler then at the lake surface (Plate 315). The cooler water temperatures near the lake bottom are attributed to groundwater inflow to the lake.

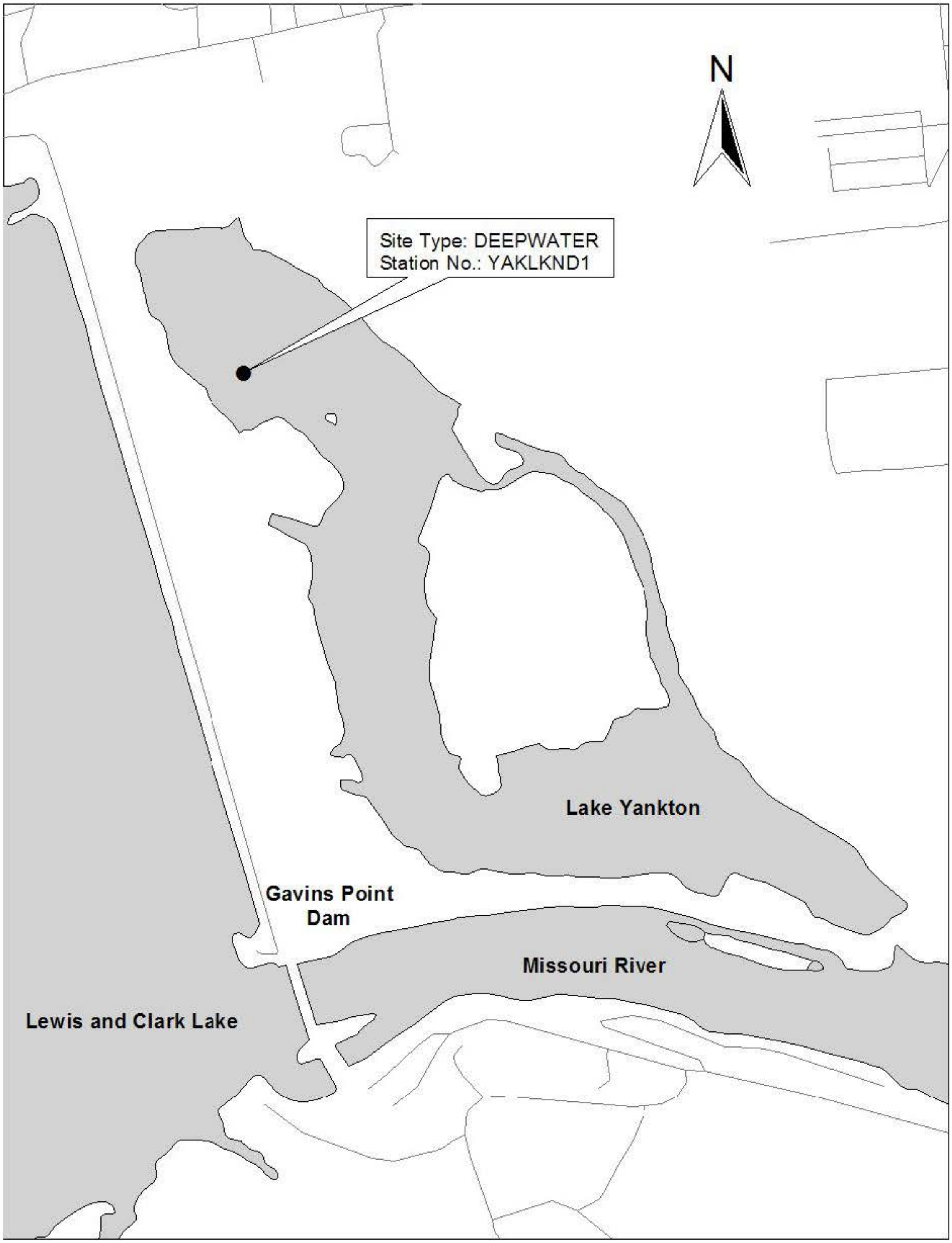

Figure 7.2. Location of water quality monitoring site on Lake Yankton.

7.3.2.3 Near-Dam Dissolved Oxygen Depth Profile Plots

Existing summer dissolved oxygen conditions were assessed for Lake Yankton based on monitoring results obtained at the deepwater ambient monitoring site during 2002 and 2006. Dissolved oxygen depth profiles were constructed from water quality data collected during the months of June, July, August, and September (Plate 316). The measured summer dissolved oxygen-depth profiles exhibited extreme variability with depth. Dissolved oxygen concentrations consistently fell below 1 mg/l in the bottom 1 to 2 meters of the lake (Plate 316). The lowest dissolved oxygen concentration measured was 0.2 mg/l.

7.3.2.4 Comparison of Near-Surface and Near-Bottom Water Quality Conditions

Near-surface and near-bottom water quality conditions monitored in Lake Yankton during the summer in 2002 and 2006 at the deepwater area (i.e., site YAKLKND1) were compared. Near-surface samples were taken to be samples collected within 1 meter of the lake surface, and near bottom-samples were taken to be samples collected within 2 meters of the lake bottom. Box plots were used to display the distribution of the collected near-surface and near-bottom measurements for the following parameters: water temperature, dissolved oxygen, oxidation-reduction potential (ORP), total Kjeldahl nitrogen, total ammonia, chemical oxygen demand, total phosphorus, total iron, and total manganese (Plate 317). Non-overlapping interquartile ranges of the adjacent surface and bottom box plots for a parameter were taken to indicate a significant difference between the measurements. The following parameters varied significantly between the surface and bottom: water temperature, dissolved oxygen, ORP, total ammonia, total iron, and total manganese (Plate 317).

7.3.2.5 Lake Trophic Status

Trophic State Index (TSI) values for Lake Yankton were calculated from monitoring data collected during the 2002 and 2006 at the deepwater ambient monitoring site (i.e., site YAKLKND1). Table 7.2 summaries the TSI values calculated for the lake. The TSI values indicate that the Lake Yankton is in a moderately eutrophic to eutrophic state.

Table 7.2. Summary of Trophic State Index (TSI) values calculated for Lake Yankton for 2002 and 2006.

TSI*	No. of Obs.	Mean	Median	Minimum	Maximum
TSI(SD)	15	61	61	51	77
TSI(TP)	15	52	51	41	72
TSI(Chl)	13	53	53	40	81
TSI(Avg)	15	56	57	47	64

* TSI(SD), TSI(TP), and TSI(Chl) are TSI index values based, respectively, on Secchi depth, total phosphorus, and chlorophyll *a* measurements. TSI(Avg) is the average of TSI values irregardless of the parameters available to calculate the average.

Note: See Section 4.1.4 for discussion of TSI calculation.

7.3.2.6 Bacteria Monitoring at the Training Dike Swimming Beach at Lake Yankton

During the 5-year period 2003 through 2007, bacteria samples were collected weekly from May through September at the Training Dike swimming beach located on Lake Yankton. Table 7.3 summarizes the results of the bacteria sampling. The geometric means were calculated as running geometric means for five consecutive weekly bacteria samples and nondetects were set to 1. The bacteria

sampling results were compared to following bacteria criteria for support of "full-body contact" recreation:

<u>Fecal Coliform:</u>

Bacteria of the fecal coliform group should not exceed a geometric mean of 200/100ml, nor equal or exceed 400/100ml, in more than 10% of the samples. These criteria are based on a minimum of five samples taken within a 30-day period.

<u>*E. coli*:</u>

E. coli bacteria should not exceed a geometric mean of 126/100ml. For increased confidence of the criteria, the geometric mean should be based on a minimum of five samples taken within a 30-day period. Single sample maximum allowable density for designated bathing beaches is 235/100ml.

Based on these criteria, "full-body contact" recreation was fully supported at the Training Dike swimming beach on Lake Yankton during the May through September recreational season during the 5-year period of 2003 through 2007.

Table 7.3. Summary of weekly (May through September) bacteria sampling conducted at the Training Dike swimming beach on Lake Yankton during the 5-year period 2003 through 2007.

	Fecal Coliform Bacteria	***E. coli* Bacteria**
Number of Samples	105	104
Mean	18	15
Median	4	1
Minimum	n.d.	n.d.
Maximum	216	357
Percent of Fecal Coliform samples exceeding 400/100ml	0%	-----
Percent of *E. coli* samples exceeding 235/100ml	-----	1%
• **Geometric Mean**		
Number of Geomeans	86	86
Average	6	5
Median	4	3
Minimum	1	1
Maximum	47	37
Number of Fecal Coliform geomeans exceeding 200/100ml	0	-----
Number of *E. coli* geomeans exceeding 126/100ml	-----	0

n.d. = Not detected.

Note: Not detected values set to 1 to calculate mean and geometric mean.

7.3.3 WATER QUALITY TRENDS (1980 THROUGH 2006)

Water quality trends over the period of 1982 through 2006 were determined for Lake Yankton for Secchi depth, total phosphorus, chlorophyll *a*, and TSI (i.e., trophic status). The assessment was based on near-surface sampling of water quality conditions in the lake during the months of May through October at the deepwater site (i.e., site YAKLKND1). Plate 318 displays a scatter-plot of the collected data for the four parameters and a linear regression trend line. For the assessment period, it appears that Lake Yankton exhibited decreasing transparency (i.e. Secchi depth), slightly decreasing concentrations of chlorophyll *a*, and slightly increasing levels of total phosphorus. Over the 25-year period, the lake has generally remained in a moderately eutrophic to eutrophic state with calculated TSI values showing a slight increasing trend (Plate 318).

8 WATER QUALITY MONITORING AND MANAGEMENT ACTIVITIES PLANNED FOR FUTURE YEARS

8.1 WATER QUALITY DATA COLLECTION

A tentative schedule of water quality monitoring targeted for implementation over the next 5 years is given in Table 8.1. The identified data collection activities are considered the minimum needed to allow for the annual assessment of water quality conditions at District projects and the preparation of project-specific water quality reports and water quality management objectives for the Mainstem System Projects. The actual monitoring activities that are implemented will be dependent upon the availability of future resources.

8.2 PROJECT-SPECIFIC WATER QUALITY MANAGEMENT PLANNING

Corps guidance for water quality and environmental management at civil works projects (USACE, 1995) identifies the need to develop specific water quality management objectives for each project and to outline procedures to be implemented to meet those objectives. The identified objectives and procedures are to be included in the project water control plans. The water quality management objectives are to be reviewed and updated as needed, but at least every 10 years.

The Omaha District's intent is to develop water quality management objectives for Mainstem System project based on the findings presented in project-specific water quality reports. Therefore, it is important that the project-specific report for a project be updated prior to the development or update of the water quality management objectives for the project. This will ensure that the water quality management objectives for the projects address all of the known surface water quality issues and concerns. Where data are lacking or water quality issues need to be further evaluated, monitoring should be implemented to address these data needs prior to the preparation of the project-specific water quality report. Water quality management objectives will be developed in coordination with project operations staff and, as appropriate, the Northwestern Division's Missouri River Basin Water management Division (MRBWMD). The project water quality management objectives will be provided to the District's Engineering and Operation Divisions and the MRBWMD for incorporation into Project Water Control Manuals and Master Plans.

The CE-QUAL-W2 hydrodynamic and water quality model is being applied to facilitate the development of project-specific water quality reports and project-specific water quality management objectives. The tentative schedule for implementing these water-quality management planning activities on the Mainstem System projects is given in Table 8.2.

Table 8.1. Water quality monitoring planned by the District at Missouri River Mainstem System Projects the next 5 years and the intended data collection approach. Actual monitoring activities implemented will be dependent upon available resources.

Mainstem Project Areas to be Monitored	**Long-Term Fixed Station Monitoring**	**Intensive Surveys**	**Special Studies**	**Watershed Assessments**	**Investigative Monitoring**
• Fort Peck		*	X[c]		X[e]
- Fort Peck Reservoir (3 Sites: Near-dam, Hell Creek, and Rock Creek)	X[a]				
- Missouri River Inflow to Fort Peck Reservoir (near Landusky, MT)	X[a]				
- Fort Peck Powerplant ("Raw-Water" Supply Line)	X[a]				
• Garrison		*	X[d]		X[e]
- Garrison Reservoir (4 Sites: Near-dam, Beulah Bay, Deepwater Bay, New Town)	X[a]				
- Missouri River Inflow to Garrison Reservoir (near Williston, ND)	X[a]				
- Garrison Powerplant ("Raw-Water" Supply Line)	X[a]				
- Lake Audubon	2009				
• Oahe					X[e]
- Oahe Reservoir (4 Sites: Near-dam, Cheyenne River Area, Whitlocks Bay, and Mobridge)	X[a]				
- Missouri River Inflow to Oahe Reservoir (near Bismarck, ND)	X[a]				
- Oahe Powerplant ("Raw-Water" Supply Line)	X[a]				
- Lake Pocasse	2009				
• Big Bend					
- Big Bend Reservoir (1 Site: Near-dam)	X[a]				
- Big Bend Reservoir (4 Sites: North Bend Area, Iron Nation Area, Cedar Creek, and Antelope Creek)		2008-2010			
- Bad River Inflow to Big Bend Reservoir (at Fort Pierre, SD)		2008-2010			
- Big Bend Powerplant ("Raw-Water" Supply Line)	X[a]				
• Fort Randall					X[e]
- Fort Randall Reservoir (1 Site: Near-dam)	X[a]				
- Fort Randall Reservoir (6 Sites: Pease Creek, Platte Creek, Snake Creek, Elm Creek, White River, Chamberlain)		2006-2008			
- White River Inflow to Fort Randall Reservoir (near Oacoma, SD)		2006-2008			
- Fort Randall Powerplant ("Raw-Water" Supply Line)	X[a]				
• Gavins Point	X[a]				X[e]
- Gavins Point Reservoir (1 Site: Near-dam)	X[a]				
- Gavins Point Reservoir (4 Sites: Weigand, Bloomfield, Devils Nest, and Charley Creek)		2008-2010			
- Niobrara River Inflow to Missouri River (near Niobrara, NE)		2008-2010			
- Gavins Point Powerplant ("Raw-Water" Supply Line)	X[a]				
- Lake Yankton	2009				
• Missouri River – Fort Randall Dam to Rulo, Nebraska (9 Sites: Fort Randall Dam Tailwaters, RM851, Gavins Point Tailwaters, RM774, RN753, RM691, RM619, RM563, RM498)	X[b]				X[e]

Table 8.1. (Continued)

* A 3-year intensive survey was completed at Garrison in 2005, Fort Peck in 2006, and Oahe in 2007.
[a] To be monitored every year.
[b] Will be monitored in 2008 and 2009. The level of monitoring after 2009 will be dependent upon the continuance of a monitoring partnership with the Nebraska Department of Environmental Quality.
[c] Special Study will be implemented, as necessary, to facilitate application of a Scoping Study to evaluate the feasibility of constructing a "multi-level" intake structure at Fort Peck Dam to allow better management of the water temperature of water discharged through the Fort Peck powerplant.
[d] Special Study will be implemented, as necessary during current drought conditions, to facilitate application of short-term water quality measures at Garrison Dam for the management of coldwater fishery habitat in Garrison Reservoir.
[e] Investigative Monitoring will be conducted as necessary and appropriate.

Table 8.2. Tentative schedule for water quality management planning activities for the Mainstem System Projects.

Planning Activity	Fort Peck	Garrison	Oahe	Big Bend	Fort Randall	Gavins Point	Missouri River*
Ambient water quality monitoring	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Conduct 3-year intensive water quality survey	Completed**	Completed**	Completed**	2008-10	2006-08	2009-11	***
Prepare Water Quality Special Study Report (Findings of the 3-year intensive water quality survey)	Completed (2007)	Completed (2006)	Completed (2008)	2011	2009	2012	2013
Application of CE-QUAL-W2 hydrodynamic and water quality model	2008	Completed (2007)	2009	2011	2010	2012	2013
Prepare Water Quality Special Study Report (Application of the CE-QUAL-W2 Model)	2009	2008	2010	2012	2011	2013	2014
Prepare Project-Specific Water Quality Report	2010	2009	2011	2013	2012	2014	2015
Develop project-specific water quality management objectives	2010	2009	2011	2013	2012	2014	2015

* Downstream of Gavins Point Dam.
** 3-year intensive surveys completed at Garrison, Fort Peck, and Oahe in 2005, 2006, and 2007, respectively.
*** Water quality data needs may be addressed with ongoing ambient water quality monitoring.

8.3 TOTAL MAXIMUM DAILY LOADS (TMDLS)

The District will participate, as appropriate, as a stakeholder in the development and implementation of TMDLs on water bodies that involve Corps civil works projects.

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10 PLATES

Plate 1. Summary of monthly (May through September) water quality conditions monitored in Fort Peck Reservoir near Fort Peck Dam (Site FTPLK1772A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	24	2204.0	2203 1	2199.4	2213.6	-----	-----	-----
Water Temperature (C)	0.1	1,153	12.8	12 1	5.6	25.5	26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	1,153	8.7	9.0	4.6	11.8	≥ 5.0	2	<1%
Dissolved Oxygen (% Sat.)	0.1	1,153	86.2	90 9	44.6	107.4	-----	-----	-----
Specific Conductance (umho/cm)	1	1,153	508	505	364	577	-----	-----	-----
pH (S.U.)	0.1	1,105	8.2	8 1	7.5	8.7	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	1,072	5.3	2 5	0.1	33.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	1,051	378	373	279	526	-----	-----	-----
Secchi Depth (in.)	1	22	136	142	56	216	-----	-----	-----
Alkalinity, Total (mg/l)	7	55	158	160	134	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	56	-----	0.03	n.d.	0.58	4.6 [1,2], 2.4[1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	49	2.4	2.4	1.1	3.8	-----	-----	-----
Chemical Oxygen Demand, Total (mg/l)	2	26	7	6	n.d.	15	-----	-----	-----
Chloride (mg/l)	1	22	8	8	7	9	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	696	-----	n.d.	n.d	4	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	24	-----	1	n.d.	4	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	33	340	338	260	420	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	57	0.3	0 2	n.d.	1.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	57	-----	n.d.	n.d.	0.13	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	47	-----	0.02	n.d.	0.11	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	57	0.07	0.04	n.d.	0.66	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	57	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	43	118	120	37	130	-----	-----	-----
Suspended Solids, Total (mg/l)	4	57	-----	n.d.	n.d.	14	-----	-----	-----
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	0.3	-----	-----	-----

n.d. = Not detected.
*   Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).
*** [1] Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.
[2] Acute criterion for aquatic life.
[3] Chronic criterion for aquatic life.

Plate 2. Summary of monthly (June through September) water quality conditions monitored in Fort Peck Reservoir near Skunk Coulee Bay (site FTPLK1778DW) during the period 2004 through 2006.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	2203.0	2202.9	2199.9	2206.2	-----	-----	-----
Water Temperature (C)	0.1	498	15.0	14.6	8.5	26.3	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	468	8.3	8.4	5.7	10.0	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	468	86.5	90.9	57.1	106.5	-----	-----	-----
Specific Conductance (umho/cm)	1	468	497	493	422	545	-----	-----	-----
pH (S.U.)	0.1	430	8.2	8.3	7.4	8.7	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	468	5.7	2.5	0.1	27.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	468	381	361	284	534	-----	-----	-----
Secchi Depth (in)	1	12	148	132	102	250	-----	-----	-----

*   Results are a combination of all sampling depths.
** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean)

Plate 3. Summary of monthly (June through September) water quality conditions monitored in Fort Peck Reservoir near The Pines Recreation Area (site FTPLK1789DW) during the period 2004 through 2006.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	2203.0	2202.9	2199.9	2206.2	-----	-----	-----
Water Temperature (C)	0.1	413	15.4	15.0	8.9	24.4	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	413	8.0	8.3	2.2	9.7	≥ 5.0	13	3%
Dissolved Oxygen (% Sat.)	0.1	413	83.7	89.0	20.7	107.1	-----	-----	-----
Specific Conductance (umho/cm)	1	413	494	490	416	559	-----	-----	-----
pH (S.U.)	0.1	379	8.2	8.3	6.9	8.8	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	412	6.8	3.3	0.1	40.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	413	370	344	136	528	-----	-----	-----
Secchi Depth (in)	1	12	118	114	78	156	-----	-----	-----
Alkalinity, Total (mg/l)	7	30	158	160	140	174	-----	-----	-----
Ammonia N, Total (mg/l)	0.01	30	-----	0.04	n.d.	0.23	3.15(1,2), 1.46(1,3)	0	0%
Carbon, Total Organic (mg/l)	0.05	30	2.4	2.4	2.2	2.8	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	8	7	6	4	12	-----	-----	-----
Chloride (mg/l)	1	8	8	8	7	8	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab	1	12	-----	1	n.d.	4	-----	-----	-----
Chlorophyll *a* (ug/l) – Field	1	412	-----	n.d.	n.d.	7.2	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	30	348	345	297	478	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	30	0.3	0.2	0.2	0.5	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	30	-----	n.d.	n.d.	0.57	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	30	0.05	0.04	n.d.	0.23	-----	-----	-----
Phosphorus, Total Dissolved (mg/l)	0.01	30	-----	0.02	n.d.	0.06	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	30	-----	n.d.	n.d.	0.05	-----	-----	-----
Sulfate (mg/l)	1	30	119	120	104	130	-----	-----	-----
Suspended Solids, Total (mg/l)	4	30	-----	n.d.	n.d.	10.0	-----	-----	-----
Microcystins (ug/l)	0.2	7	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

(1) Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.

(2) Acute criterion for aquatic life.

(3) Chronic criterion for aquatic life.

Plate 4. Summary of monthly (June through September) water quality conditions monitored in Fort Peck Reservoir near Hell Creek Bay (site FTPLK1805DW) during the period 2004 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	13	2202.8	2202.6	2200.3	2206.2	-----	-----	-----
Water Temperature (C)	0.1	311	17.0	16.8	9.5	27.4	≤ 26.7	1	<0%
Dissolved Oxygen (mg/l)	0.1	311	7.8	8.4	3.5	9.9	≥ 5.0	28	9%
Dissolved Oxygen (% Sat.)	0.1	311	84.5	89.6	35.3	111.6	-----	-----	-----
Specific Conductance (umho/cm)	1	311	501	486	413	565	-----	-----	-----
pH (S.U.)	0.1	287	8.3	8.4	7.3	9.0	≥6 5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	287	6.9	5.7	0.3	31.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	311	355	338	263	508	-----	-----	-----
Secchi Depth (in)	1	13	86	76	46	144	-----	-----	-----
Alkalinity, Total (mg/l)	7	28	155	157	140	170	-----	-----	-----
Ammonia N, Total (mg/l)	0.01	28	-----	0.03	n.d.	0.21	2.6[1,2], 1 1[1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	26	2.6	2.6	2.0	4.1	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	14	7	8	n.d.	18	-----	-----	-----
Chloride (mg/l)	1	14	8	8	7	8	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab	1	13	3	3	1	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Field	1	213	-----	n.d.	n.d.	13	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	28	347	350	294	422	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	28	0.3	0.3	n.d.	0.6	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	28	-----	n.d.	n.d.	0.14	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	28	0.06	0.03	n.d.	0 34	-----	-----	-----
Phosphorus, Total Dissolved (mg/l)	0.01	28	-----	0.02	n.d.	0.24	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	28	-----	n.d.	n.d.	0.23	-----	-----	-----
Sulfate (mg/l)	1	28	118	120	93	140	-----	-----	-----
Suspended Solids, Total (mg/l)	4	28	-----	n.d.	n.d.	12	-----	-----	-----
Microcystins (ug/l)	0.2	9	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.
* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).
*** [1] Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.
[2] Acute criterion for aquatic life.
[3] Chronic criterion for aquatic life.

Plate 5. Summary of monthly (June through September) water quality conditions monitored in Fort Peck Reservoir in the Big Dry Creek Arm of the reservoir (site FTPLKBDCA01) during the period 2004 through 2006.

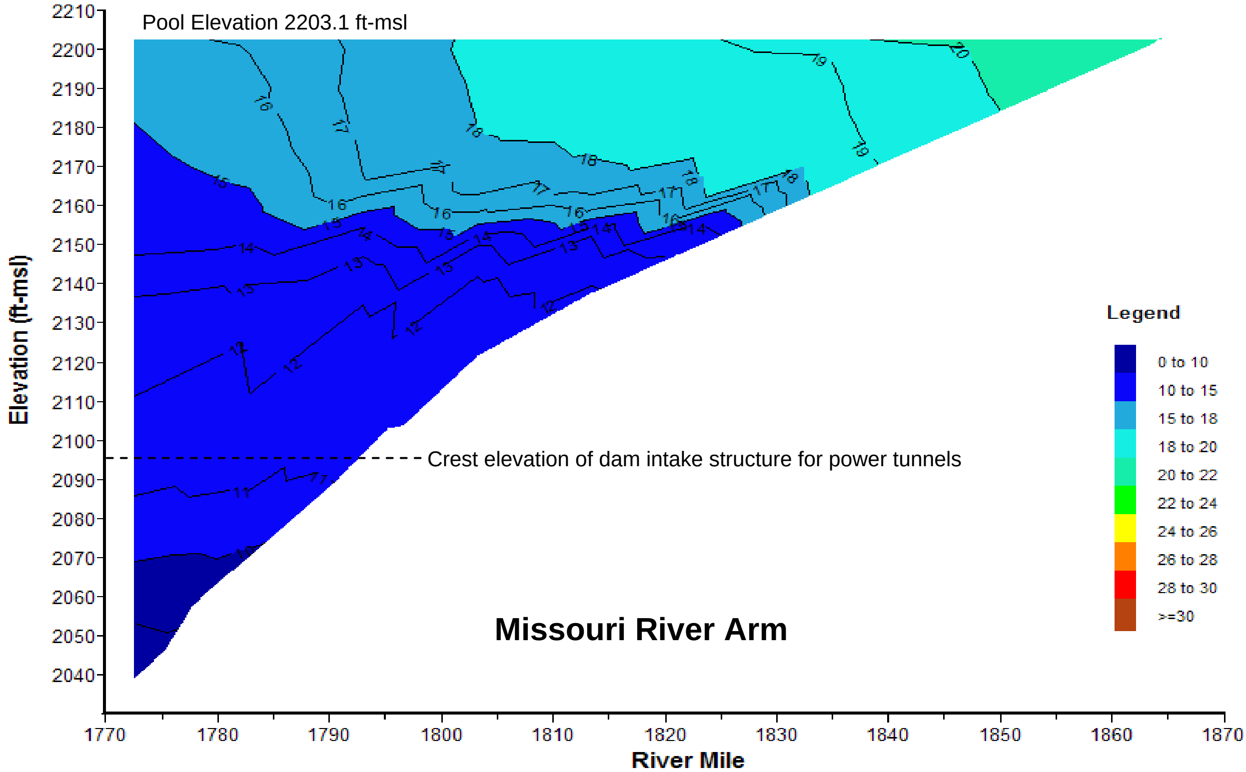
Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	2203.0	2202.9	2199.9	2206.2	-----	-----	-----
Water Temperature (C)	0.1	471	15.0	14.5	8.7	25.4	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	471	8.4	8.4	5.6	10.0	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	471	86.9	91.1	55.1	110.6	-----	-----	-----
Specific Conductance (umho/cm)	1	470	501	496	350	550	-----	-----	-----
pH (S.U.)	0.1	471	8.3	8.3	7.6	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	471	6.0	2.4	0.1	45.1	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	471	382	363	301	507	-----	-----	-----
Secchi Depth (in)	1	12	152	159	76	240	-----	-----	-----

* Results are a combination of all sampling depths.
** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

Plate 6. Summary of monthly (June through September) water quality conditions monitored in Fort Peck Reservoir near Rock Creek Bay (site FTPLKBDCA02) during the period 2004 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	16	2202.7	2202.6	2199.9	2206.2	-----	-----	-----
Water Temperature (C)	0.1	271	18.0	17.6	13.1	24.2	≤ 26.7	0	0%
Dissolved Oxygen (mg/l)	0.1	271	8.4	8.5	5.6	9.5	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	271	92.8	94.7	59.9	103.0	-----	-----	-----
Specific Conductance (umho/cm)	1	271	520	525	433	563	-----	-----	-----
pH (S.U.)	0.1	271	8.5	8.5	7.8	9.2	≥6 5 & ≤9.0	12	4%
Turbidity (NTUs)	0.1	269	6.0	4.0	0.2	25.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	271	367	353	301	492	-----	-----	-----
Secchi Depth (in)	1	16	100	98	54	172	-----	-----	-----
Alkalinity, Total (mg/l)	7	26	157	160	140	179	-----	-----	-----
Ammonia N, Total (mg/l)	0.01	26	-----	0.04	n.d.	0 25	2.1[(1,2)], 0.8[(1,3)]	0	0%
Carbon, Total Organic (mg/l)	0.05	25	2.6	2.5	1.7	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	12	7	8	n.d.	12	-----	-----	-----
Chloride (mg/l)	1	12	8	8	7	9	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab	1	14	-----	n.d.	n.d.	7	-----	-----	-----
Chlorophyll *a* (ug/l) – Field	1	198	-----	n.d.	n.d.	5	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	26	368	360	315	479	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	26	0.3	0.3	0.2	0.5	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	26	-----	n.d.	n.d.	0.17	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	25	-----	0.03	n.d.	0.13	-----	-----	-----
Phosphorus, Total Dissolved (mg/l)	0.01	26	-----	n.d.	n.d.	0.08	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	26	-----	n.d.	n.d.	0.04	-----	-----	-----
Sulfate (mg/l)	1	26	128	126	110	180	-----	-----	-----
Suspended Solids, Total (mg/l)	4	26	-----	n.d.	n.d.	10	-----	-----	-----
Microcystins (ug/l)	0.2	9	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.
* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).
*** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for the median pH and temperature conditions.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.



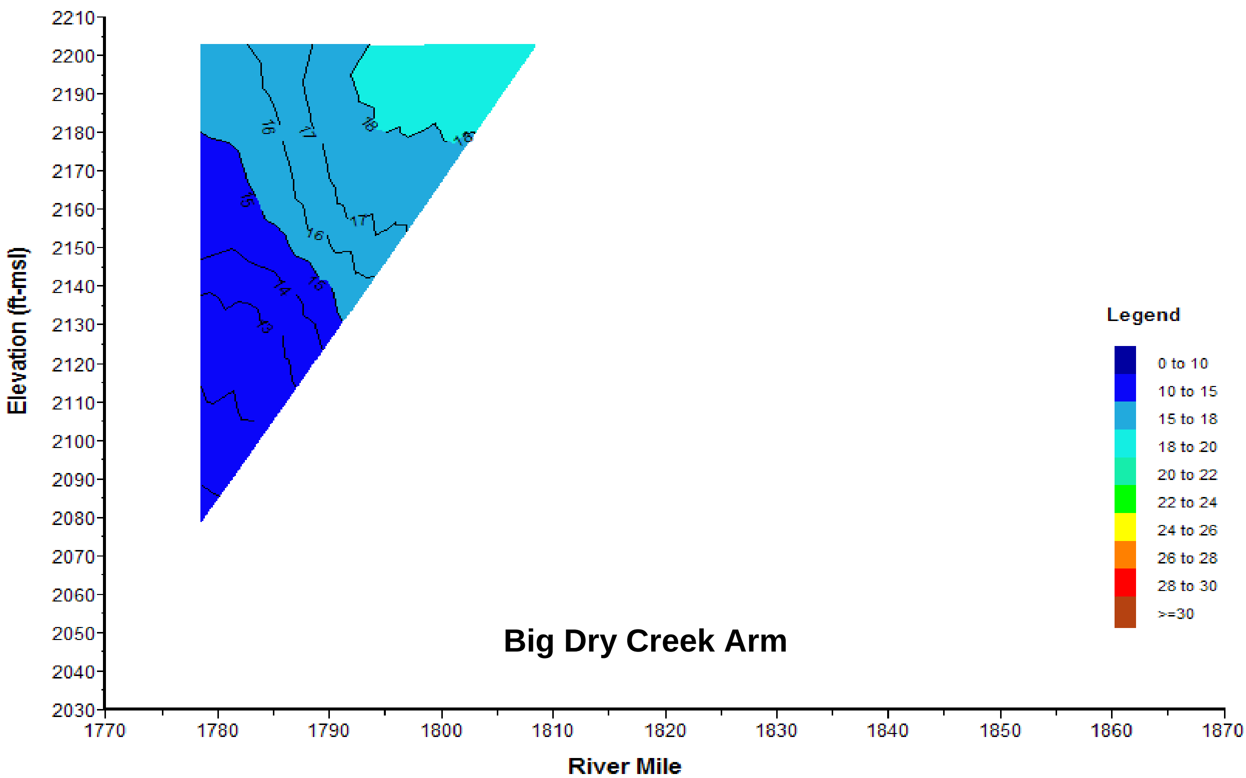
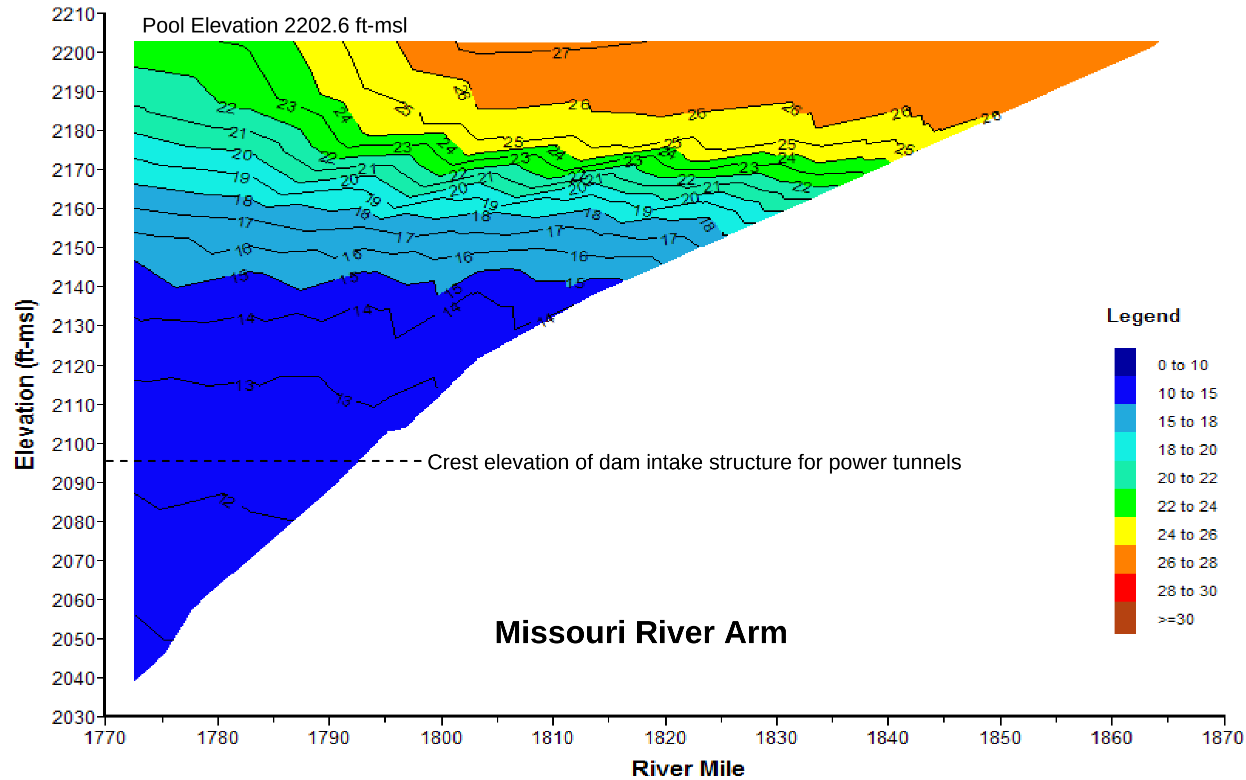


Plate 7. Longitudinal water temperature (°C) contour plot of Fort Peck Reservoir based on depth-profile water temperatures measured at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on June 26, 2007.



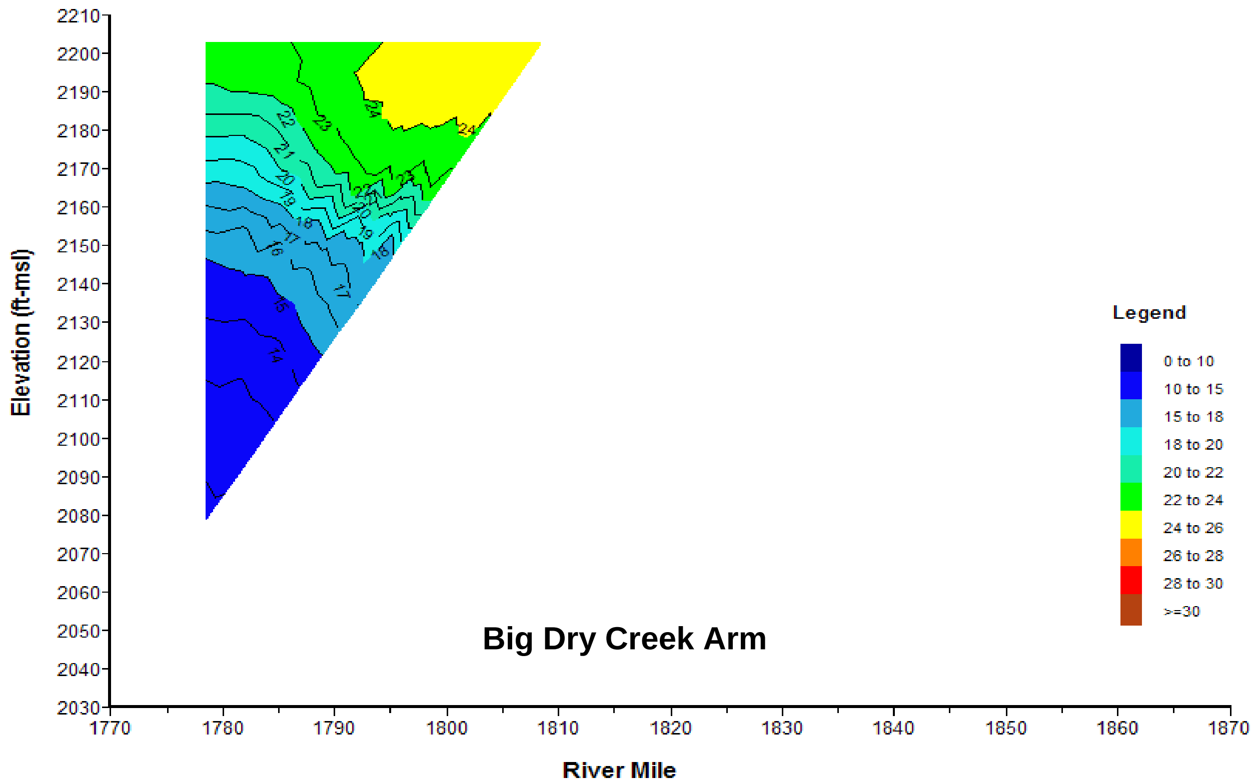


Plate 8. Longitudinal water temperature (°C) contour plot of Fort Peck Reservoir based on depth-profile water temperatures measured at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on July 25, 2007.

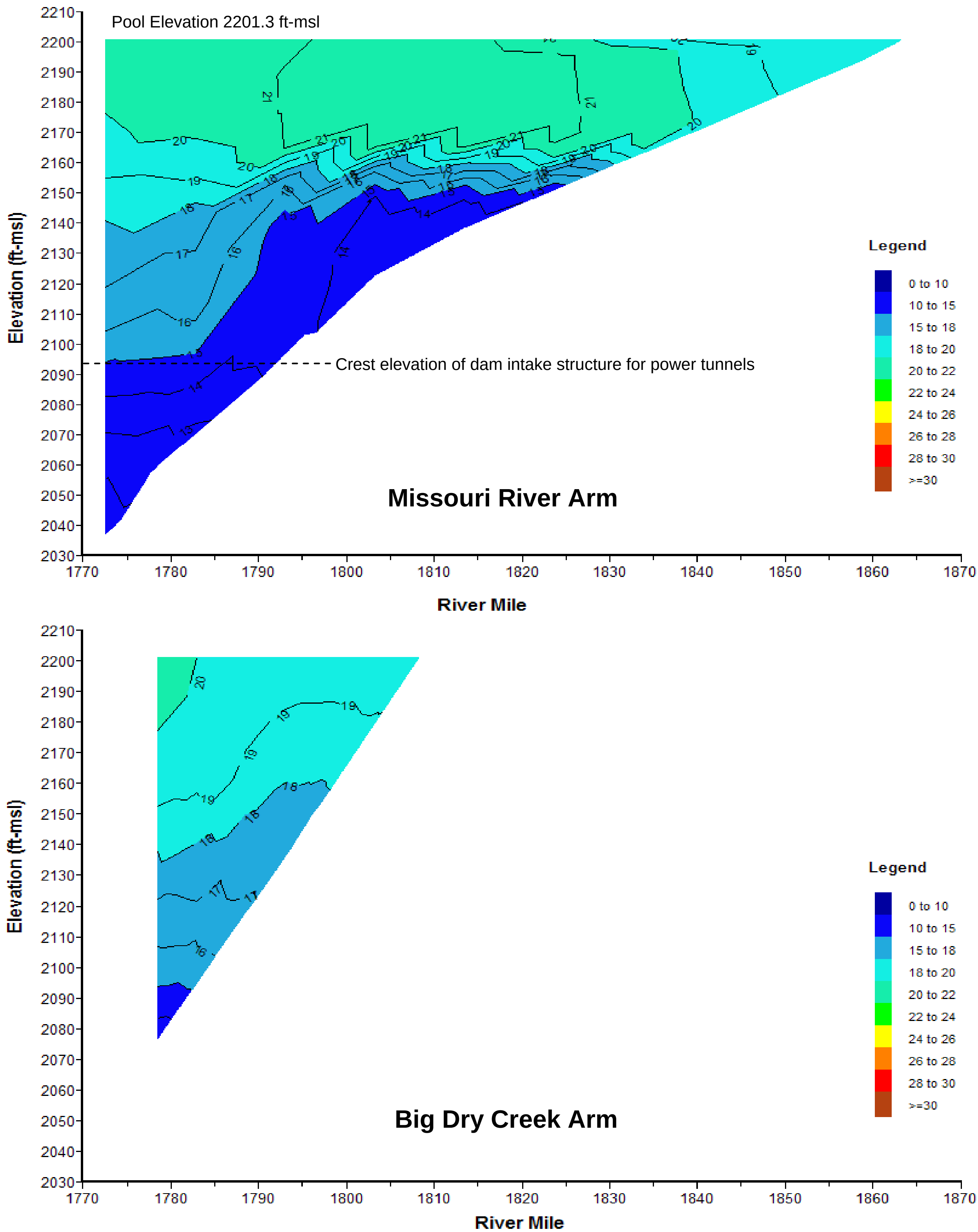


Plate 9. Longitudinal water temperature (°C) contour plot of Fort Peck Reservoir based on depth-profile water temperatures measured at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on August 22, 2007.

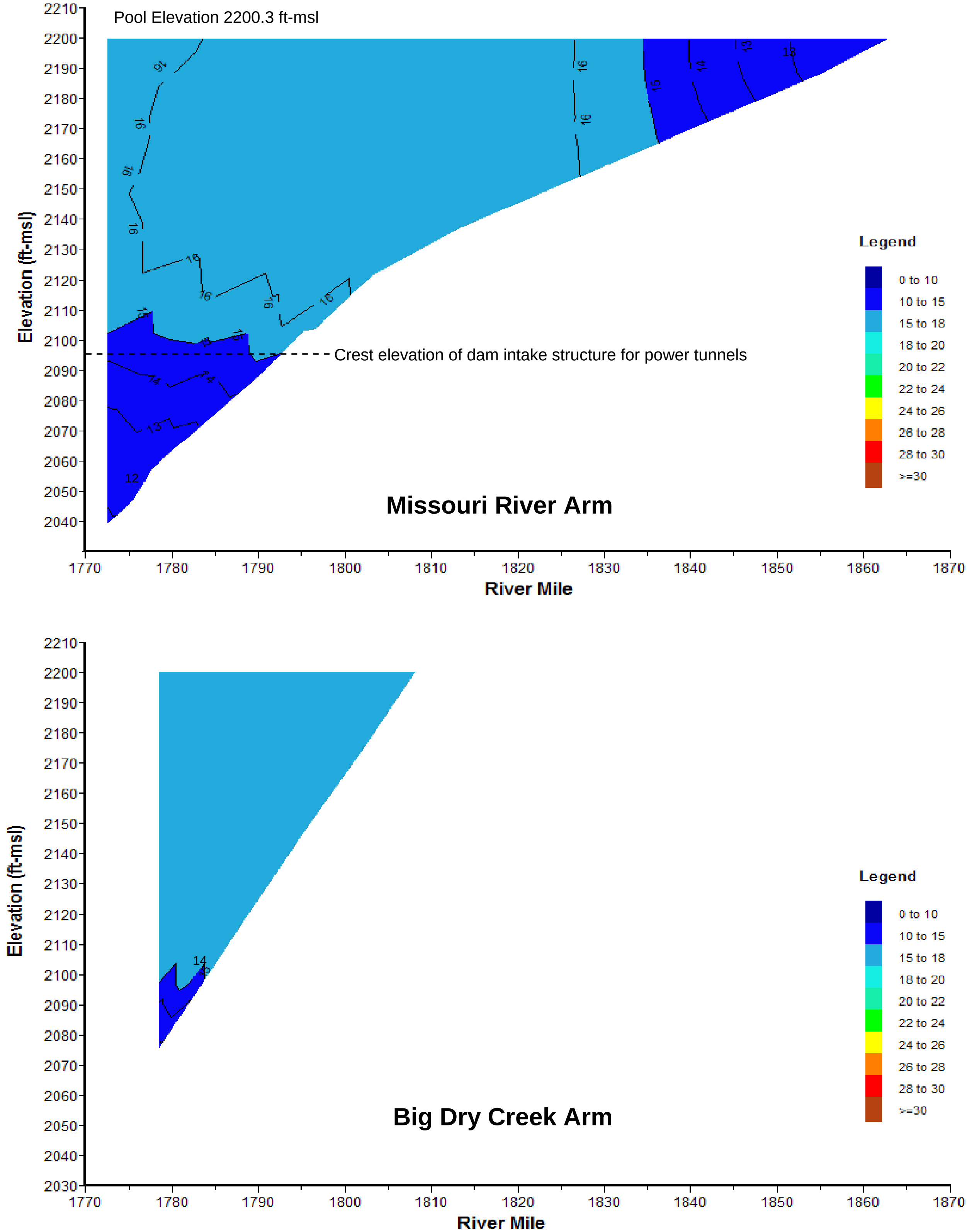


Plate 10. Longitudinal water temperature (°C) contour plot of Fort Peck Reservoir based on depth-profile water temperatures measured at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on September 26, 2007.

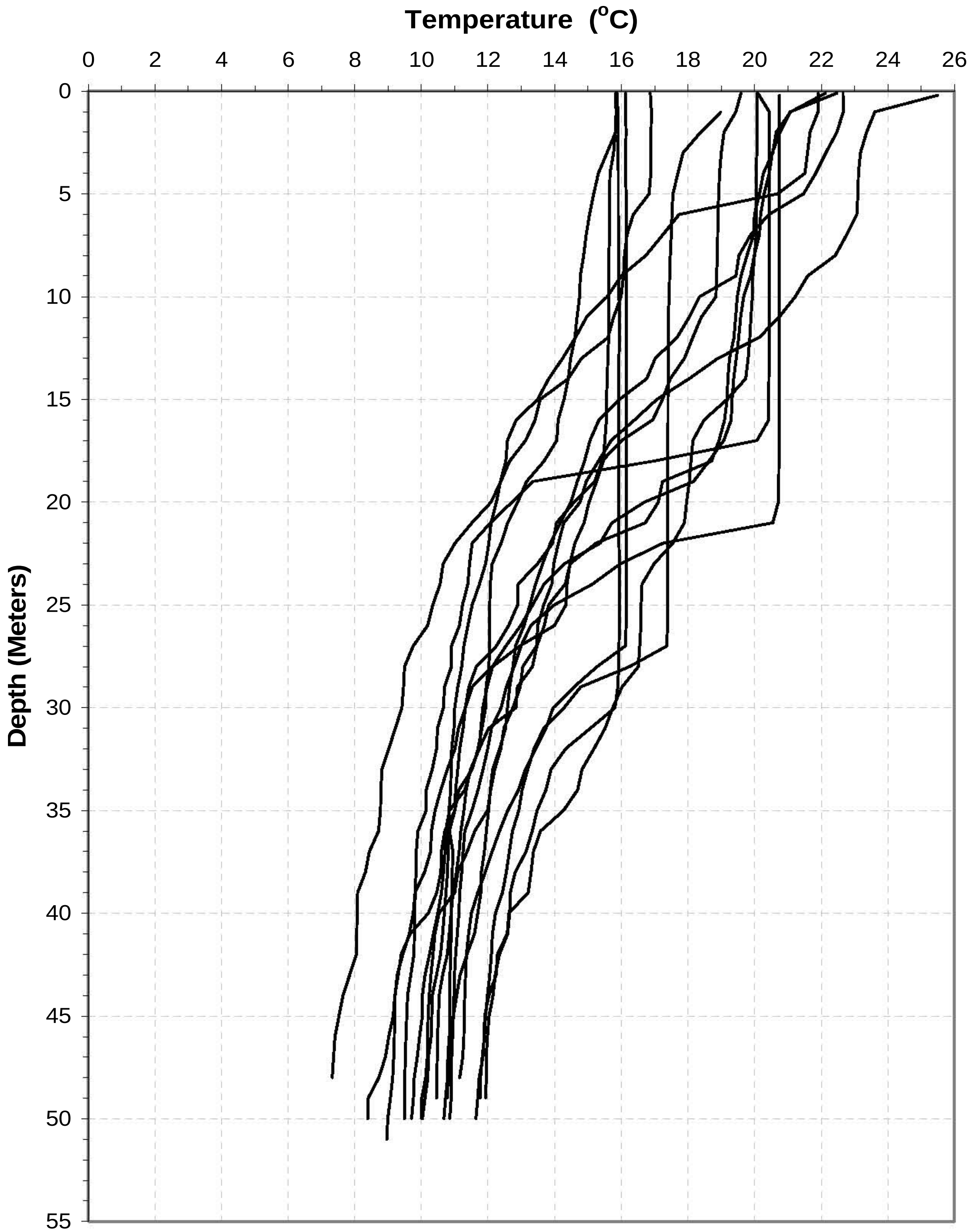


Plate 11. Temperature depth profiles for Fort Peck Reservoir compiled from data collected at the near-dam, deepwater ambient monitoring site (i.e., FTPLK1772A) during the months of June, July, August, and September over the 5-year period of 2003 to 2007.

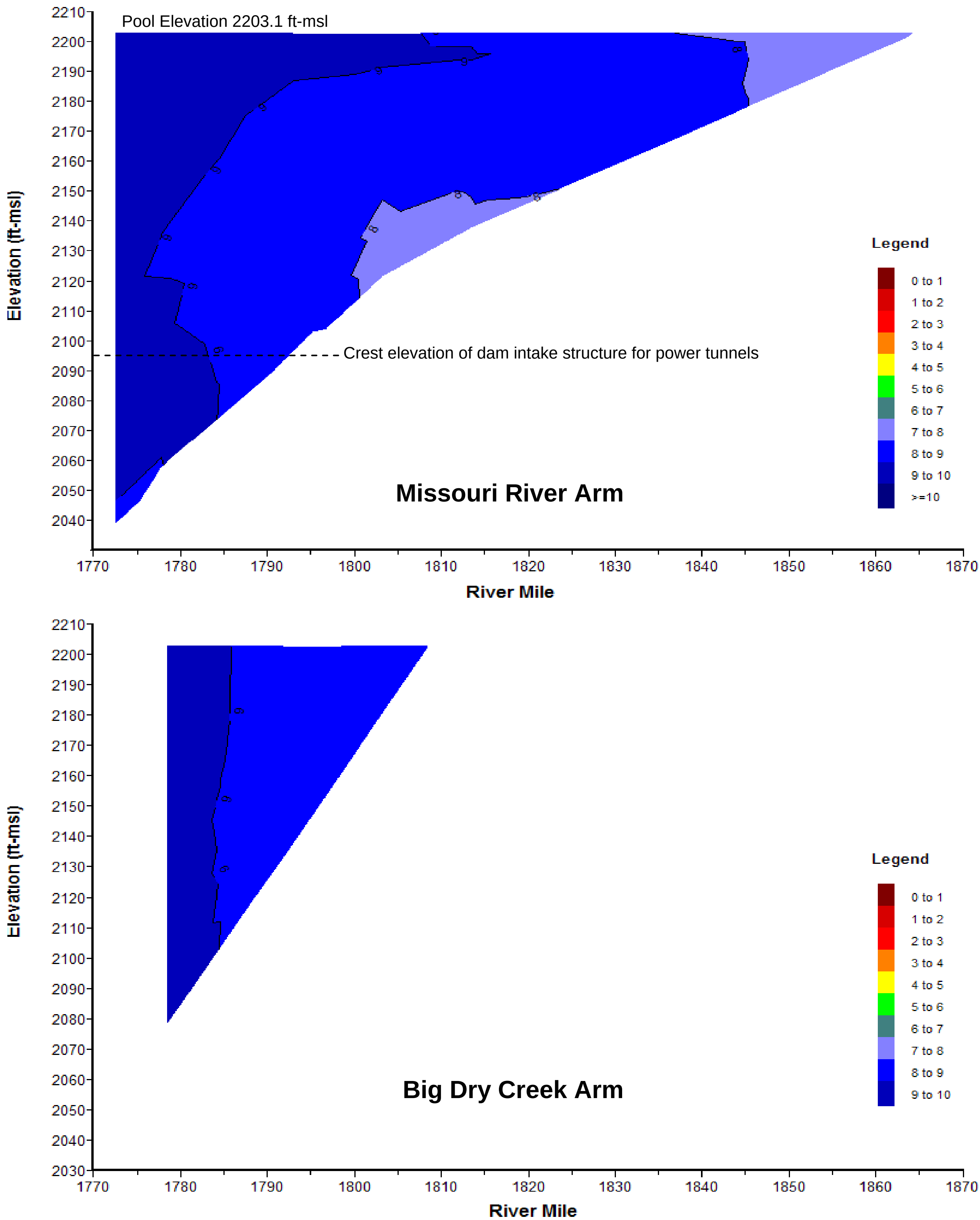


Plate 12. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Peck Reservoir based on depth-profile dissolved oxygen concentrations monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on June 26, 2007.

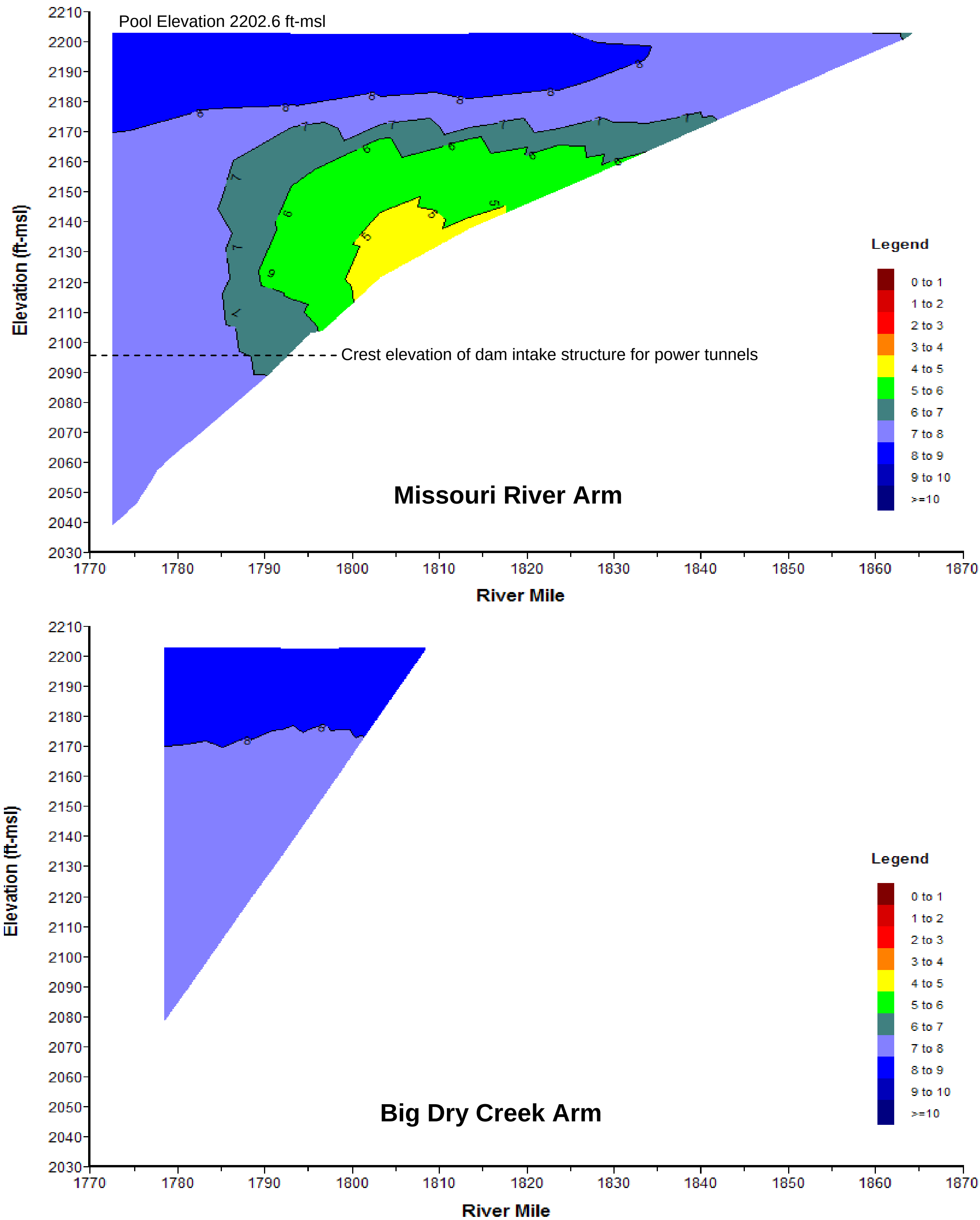
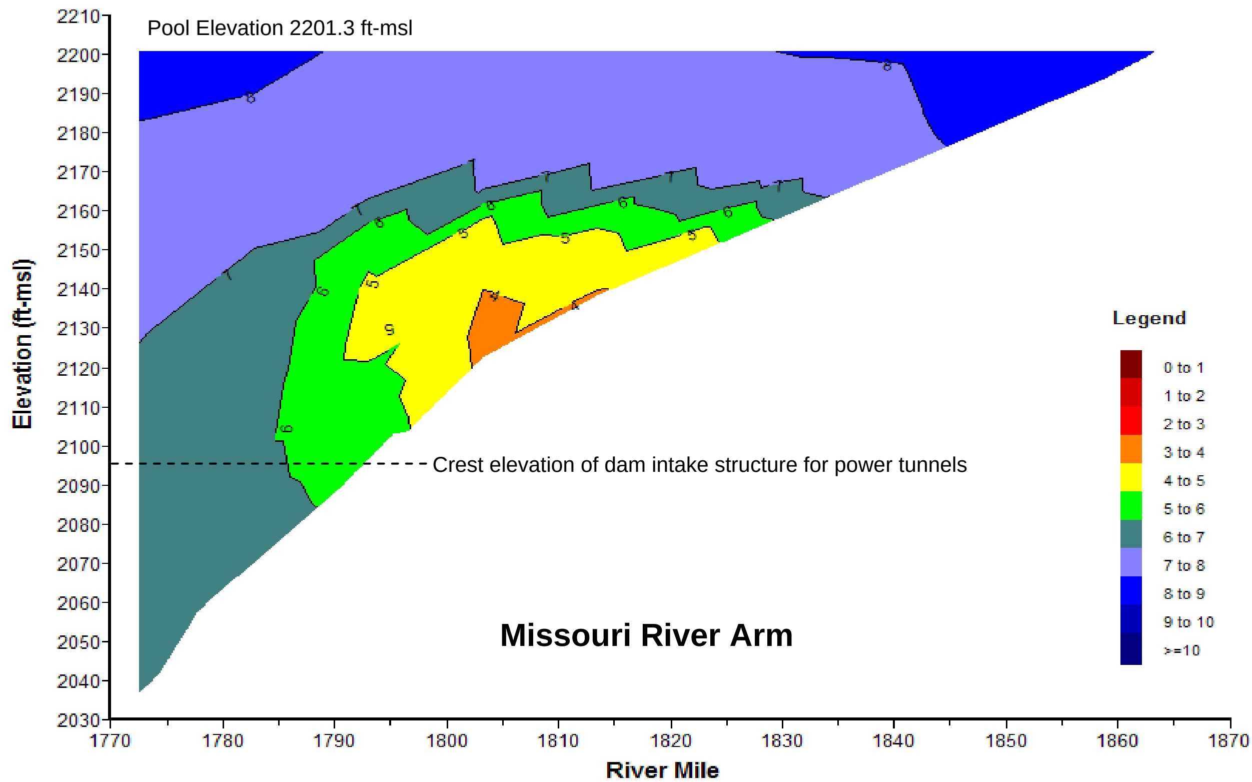


Plate 13. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Peck Reservoir based on depth-profile dissolved oxygen concentrations monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on July 25, 2007.



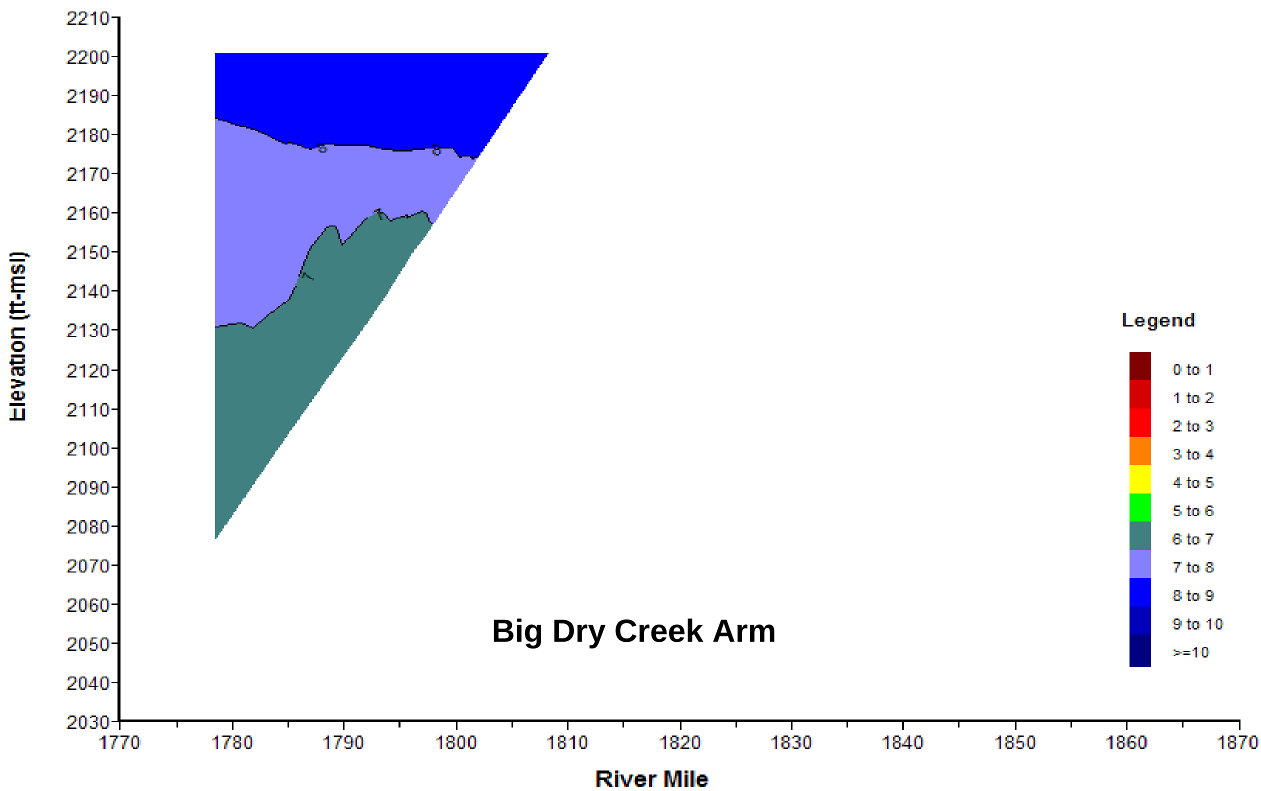
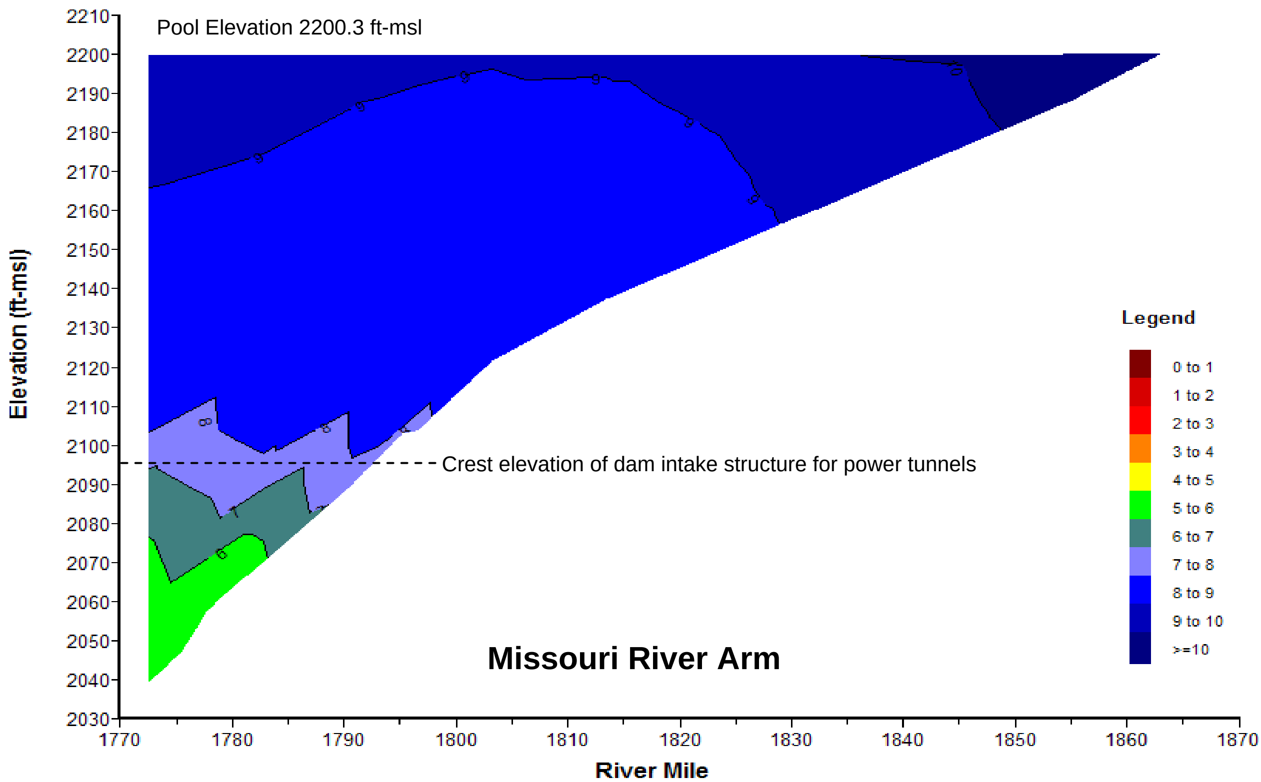


Plate 14. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Peck Reservoir based on depth-profile dissolved oxygen concentrations monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on August 22, 2007.



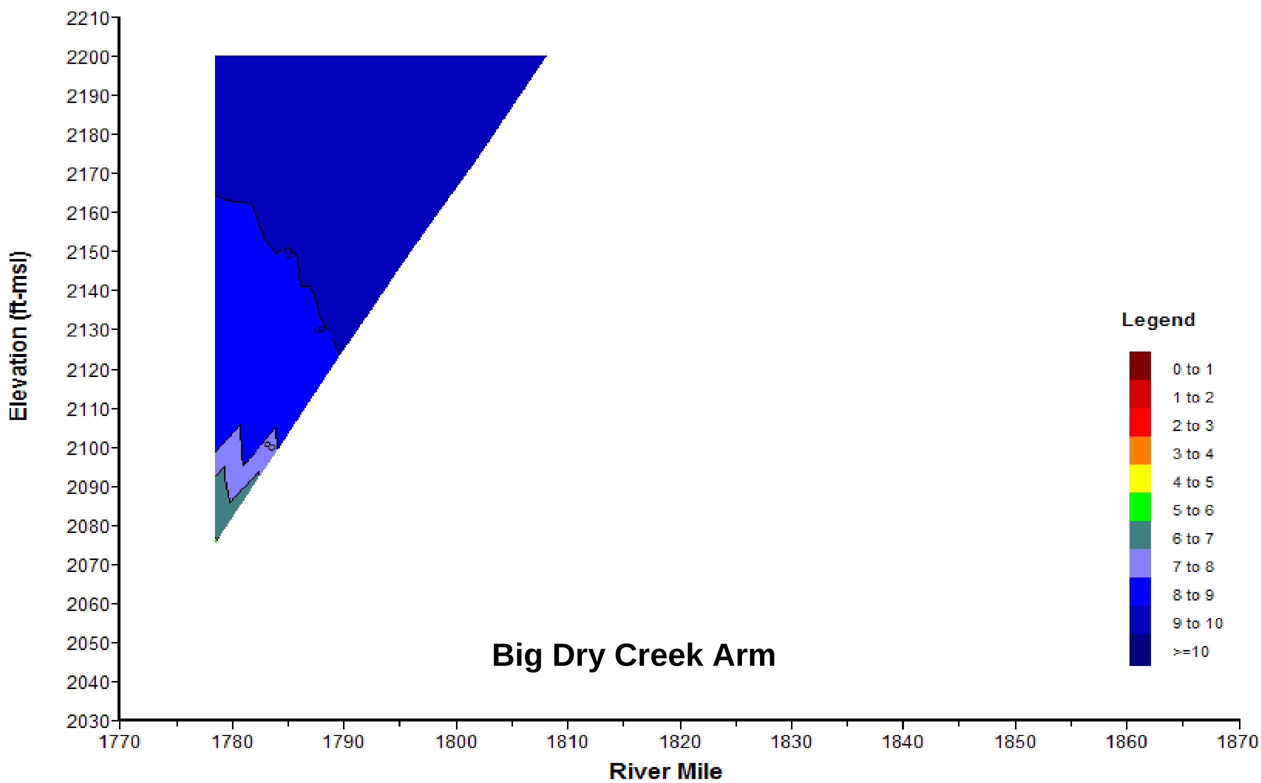


Plate 15. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Peck Reservoir based on depth-profile dissolved oxygen concentrations monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on September 26, 2007.

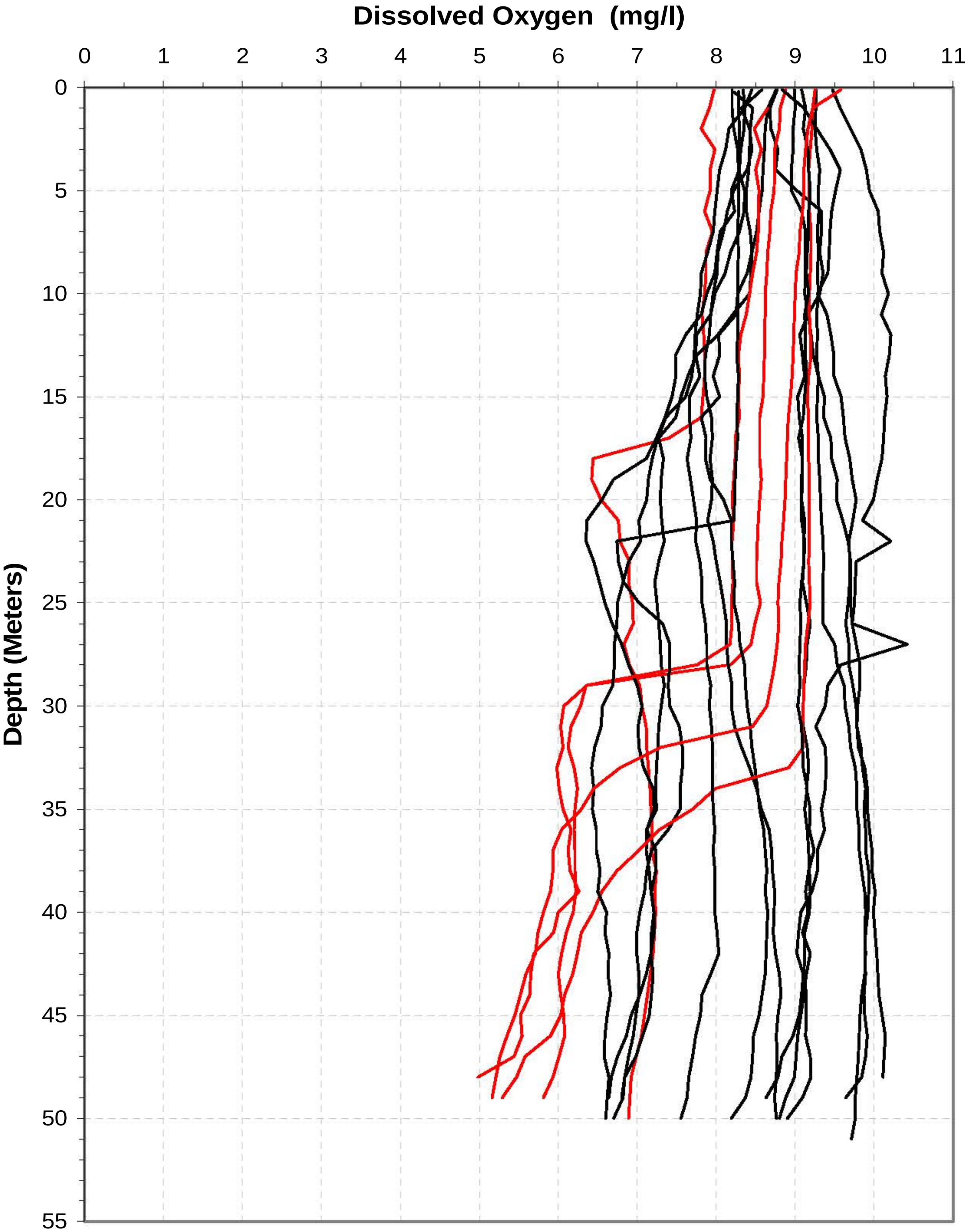
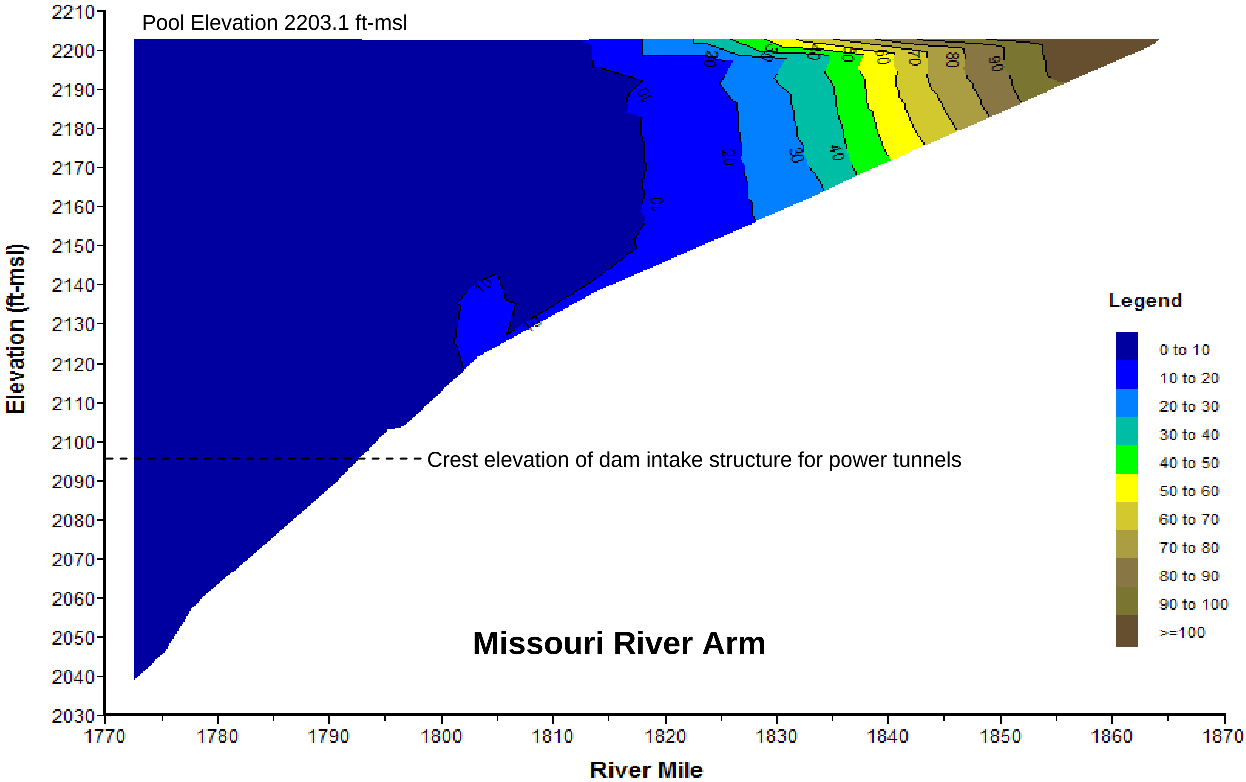


Plate 16. Dissolved oxygen depth profiles for Fort Peck Reservoir compiled from data collected at the near-dam, deepwater ambient monitoring site (i.e., FTPLK1772A) during the months of June, July, August, and September over the 5-year period of 2003 to 2007. (Note: Red profile plots were measured in the month of September.)



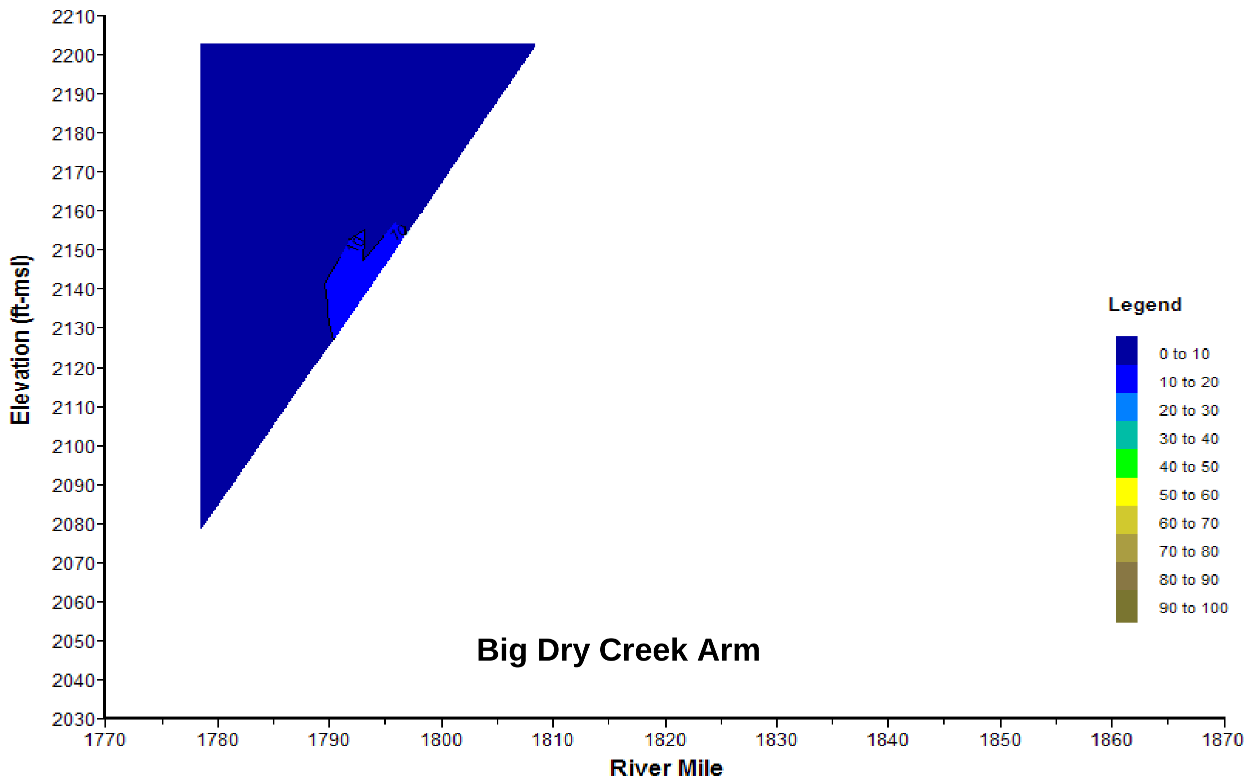
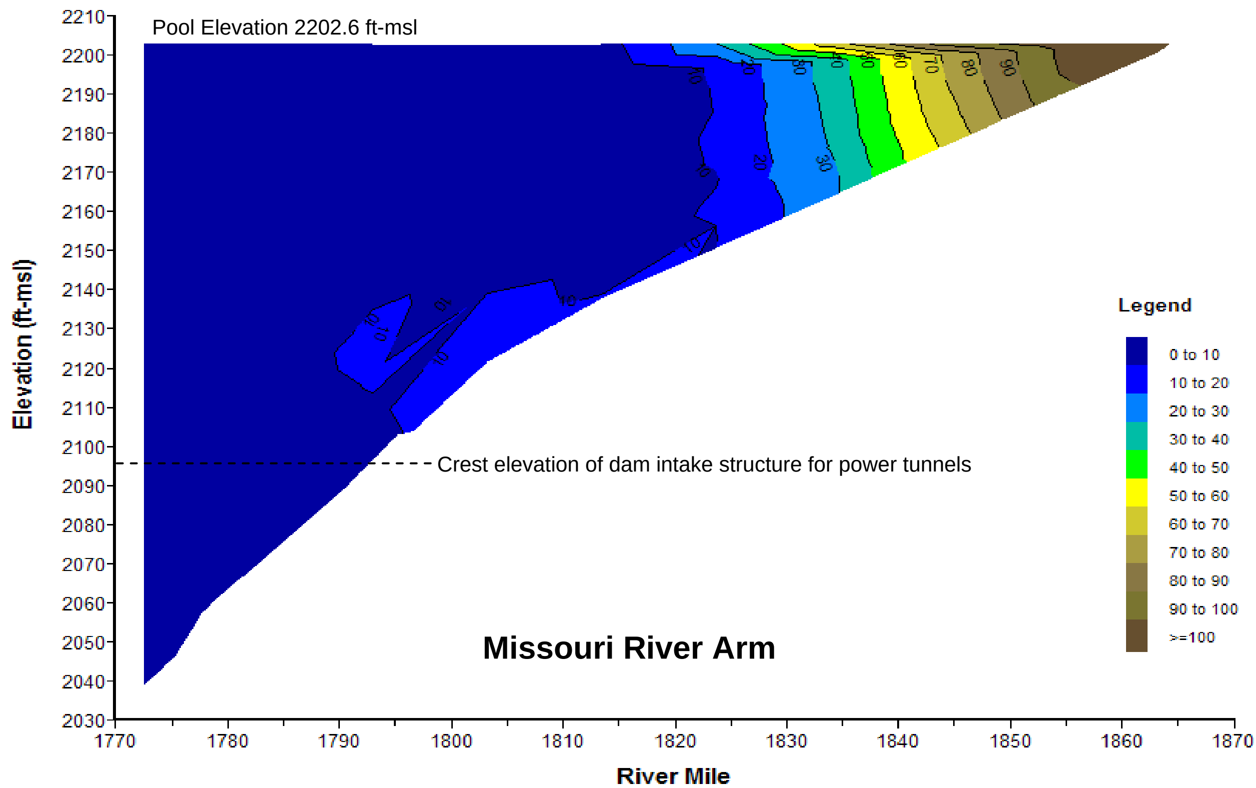


Plate 17. Longitudinal turbidity (NTU) contour plot of Fort Peck Reservoir based on depth-profile turbidity levels monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on June 26, 2007.



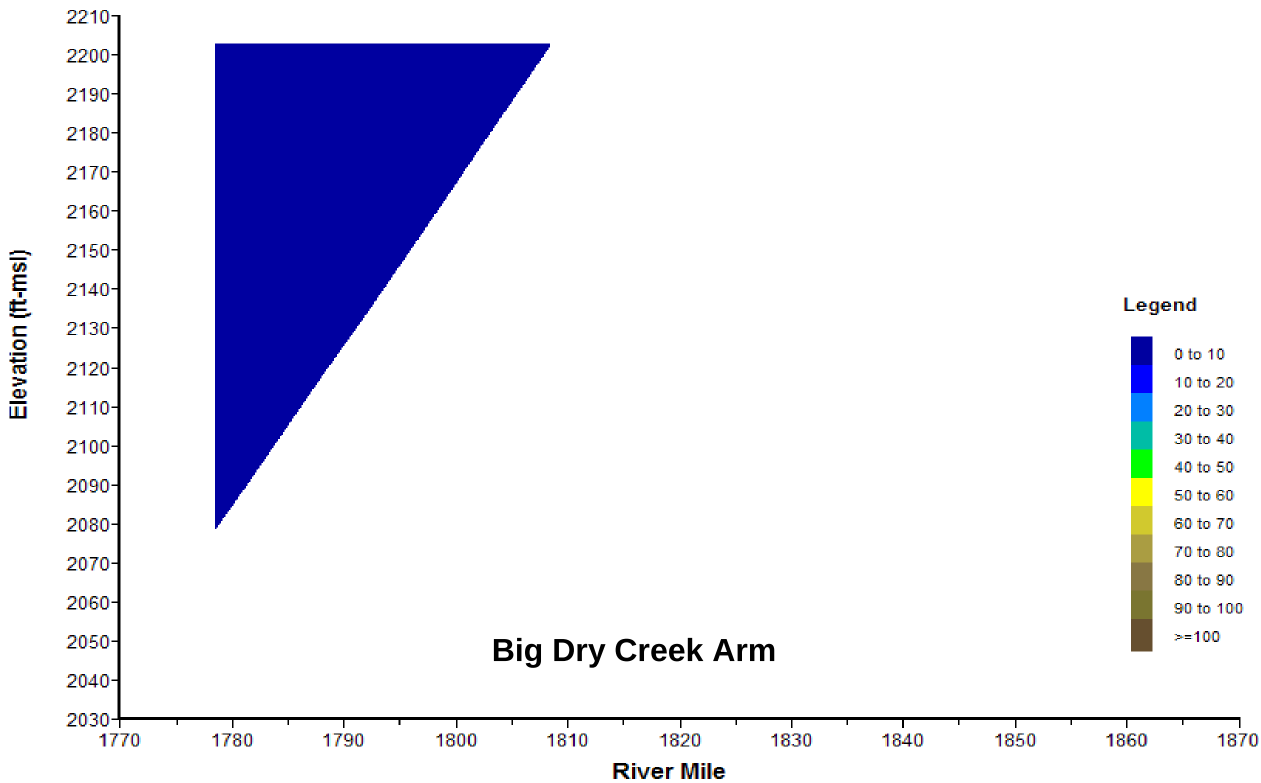
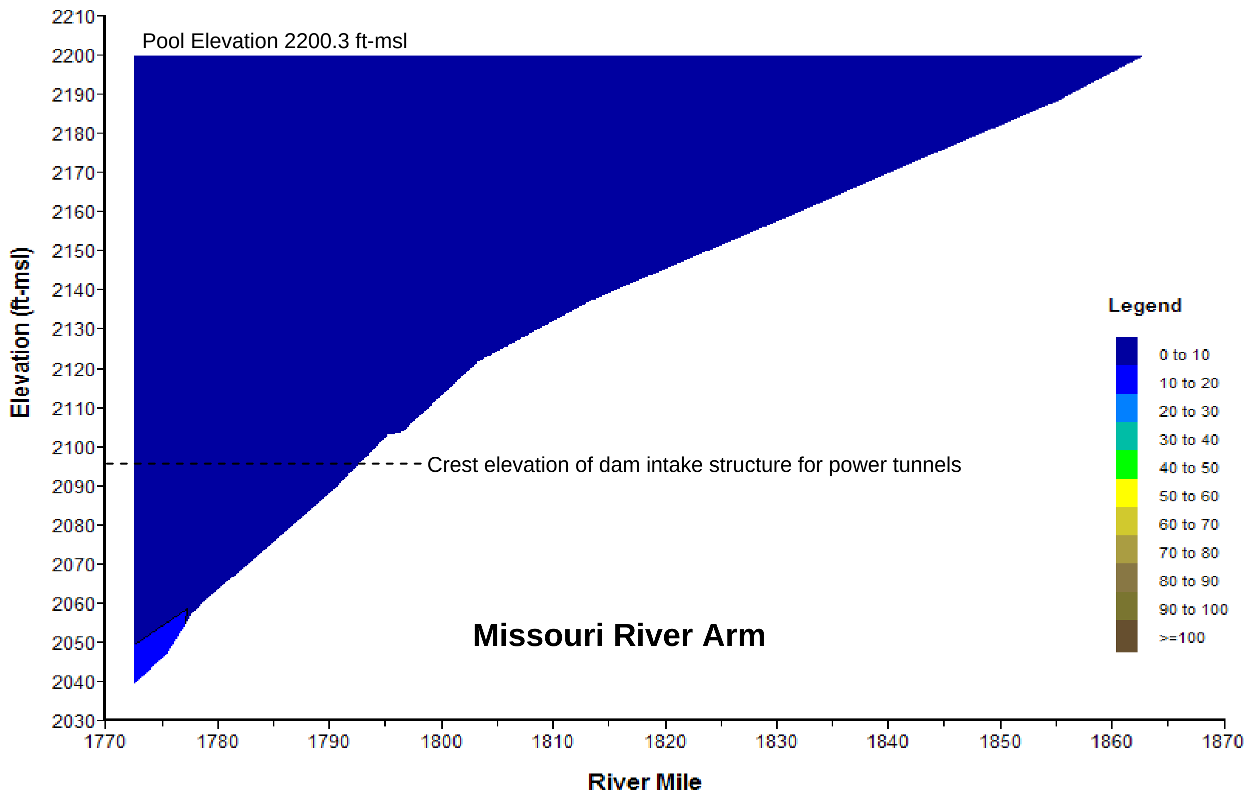


Plate 18. Longitudinal turbidity (NTU) contour plot of Fort Peck Reservoir based on depth-profile turbidity levels monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on July 25, 2007.



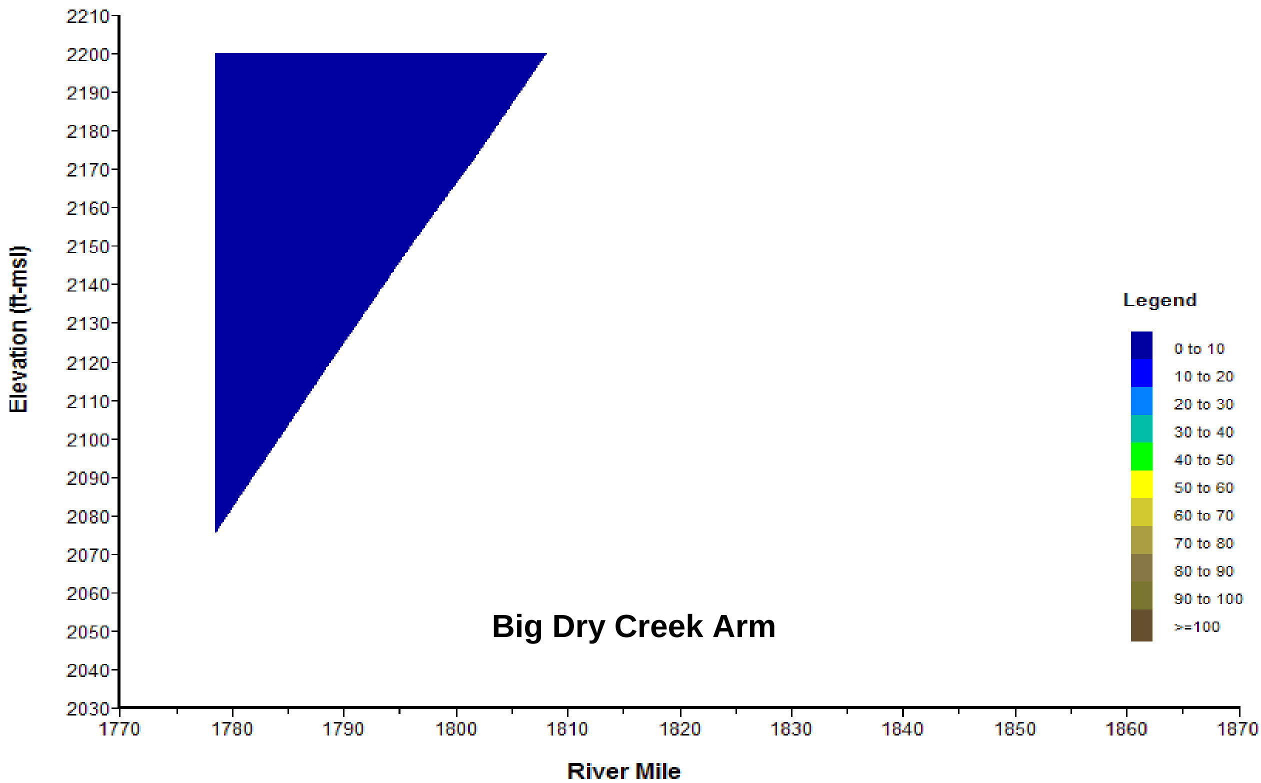


Plate 19. Longitudinal turbidity (NTU) contour plot of Fort Peck Reservoir based on depth-profile turbidity levels monitored at sites FTPLK1772A, FTPLK1805DW, FTPLKBDCA02, and FTPNFMORR1 on September 26, 2007.

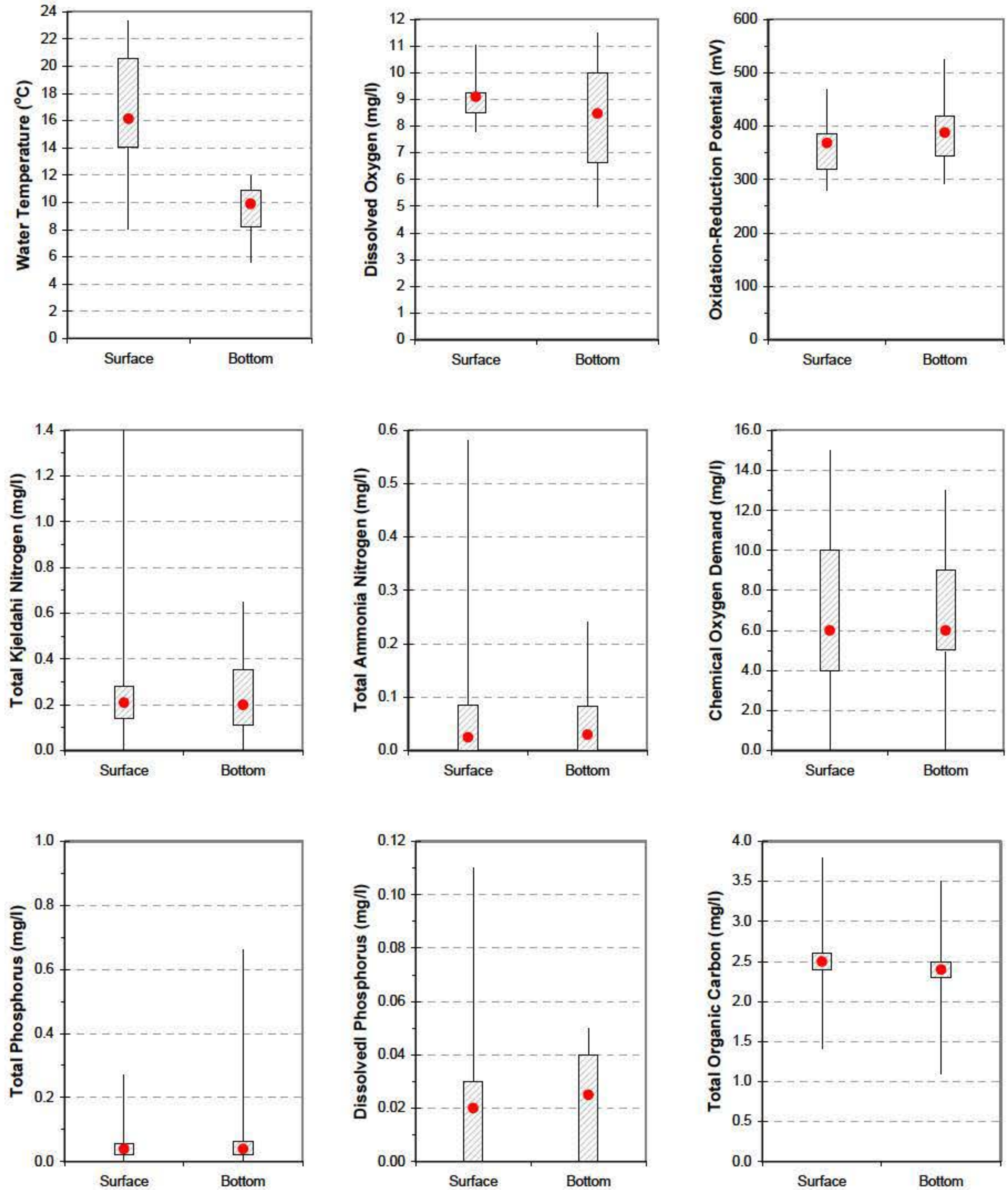


Plate 20. Box plots comparing paired surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measurements taken in Fort Peck Reservoir at site FTPLK1772A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 21. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Peck Reservoir at site FTPLK1772A during the period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
May 2004	785,288	1	0.02	0	-----	0	-----	1	0.57	2	0.41	0	-----	0	-----	0.87
Jun 2004	5,099,022	3	0 21	0	-----	0	-----	1	0.65	3	0.13	0	-----	0	-----	1.15
Jul 2004	106,065,880	3	1.00	0	-----	0	-----	1	<0.01	2	<0.01	0	-----	0	-----	0.96
Aug 2004	47,445,368	4	0.93	1	<0.01	0	-----	1	0.05	3	0.02	0	-----	0	-----	1.59
Sep 2004	47,026,614	6	0.66	7	0.10	0	-----	1	0.09	4	0.09	1	0.05	0	-----	2.11
May 2005	515,757,980	10	0.92	1	<0.01	2	0.07	0	-----	0	-----	0	-----	0	-----	1.28
Jun 2005	46,921,234	5	0.90	1	<0.01	0	-----	0	-----	1	<0.01	1	0.09	0	-----	1.61
Jul 2005	156,655,118	4	0.79	1	<0.01	0	-----	2	0.07	5	0.02	2	0.11	0	-----	1.51
Aug 2005	329,301,346	7	0.46	3	<0.01	1	<0.01	1	0.05	6	0.18	2	0.30	0	-----	2.20
Sep 2005	138,703,297	7	0.38	9	0.08	0	-----	1	<0.01	5	0.05	1	0.47	0	-----	1.62
May 2006	38,868,068	6	0.99	1	0.01	0	-----	0	-----	0	-----	0	-----	1	<0.01	1.17
Jun 2006	106,214,930	4	0.89	2	0.02	1	<0.01	1	<0.01	1	0.08	0	-----	1	<0.01	1.11
Jul 2006	99,703,362	8	0.25	3	0.01	1	0.03	1	0.01	3	0.34	2	0.35	1	0.01	2.12
Aug 2006	146,573,753	6	0.85	3	0.05	0	-----	1	0.03	2	0.07	0	-----	0	-----	1.83
Sep 2006	187,114,896	4	0.95	2	<0.01	0	-----	1	0.04	2	0.01	0	-----	0	-----	1.12
May 2007	1,351,414,254	12	0.99	2	<0.01	1	<0.01	1	<0.01	0	-----	0	-----	0	-----	0.40
Jun 2007	341,943,773	10	0.89	5	<0.01	1	0.05	1	<0.01	2	<0.01	1	<0.01	0	-----	1.49
Jul 2007	164,287,704	7	0.06	3	0.01	1	0.09	1	0.03	3	0.60	2	0.21	0	-----	1.68
Aug 2007	88,444,888	8	0.37	4	0.07	1	0.04	1	0.23	3	0.10	2	0.20	0	-----	2.16
Sep 2007	85,876,002	6	0.69	7	0.06	1	0.02	2	0.07	5	0.12	2	0.04	0	-----	2.28
Mean*	**200,210,139**	**6.05**	**0.66**	**2.75**	**0.02**	**0.50**	**0.03**	**0.95**	**0.11**	**2.60**	**0.13**	**0 80**	**0.18**	**0.15**	**<0.01**	**1.51**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 22. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Peck Reservoir at site FTPLK1805DW during the period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	40,330,095	7	0.73	0	-----	0	-----	3	0.25	1	0.01	1	0.01	0	-----	1.63
Aug 2004	77,071,993	5	0 53	0	-----	0	-----	2	0.09	6	0.25	1	0.12	0	-----	1.90
Jun 2005	1,065,980,294	6	0.97	3	0.01	2	0.02	1	<0.01	2	<0.01	0	-----	0	-----	1.39
Jul 2005	56,454,155	4	0.62	3	0.01	0	-----	2	0.27	4	0.06	1	0.04	0	-----	1.91
Aug 2005	104,295,158	8	0.36	3	0.14	0	-----	1	0.12	3	0.37	1	<0.01	0	-----	2.21
Sep 2005	224,860,040	4	0.56	4	0.09	2	0.05	2	0.15	3	0.06	2	0.08	0	-----	2.21
Jun 2006	462,062,083	8	0 94	7	0.02	2	0.01	1	0.02	0	-----	0	-----	1	<0.01	1.45
Jul 2006	339,425,190	5	0.19	5	0.10	2	0.03	1	0.22	3	0.43	1	0.03	0	-----	1.95
Oct 2006	342,710,099	9	0.72	12	0.10	1	0.01	1	0.07	3	0.10	1	<0.01	0	-----	2.19
Jun 2007	610,342,167	8	0.67	8	0.05	2	0.13	2	0.07	1	<0.01	1	0.08	0	-----	1.86
Jul 2007	110,206,693	5	0.19	5	0.05	1	<0.01	1	0.22	1	0.08	2	0.46	0	-----	1.64
Aug 2007	301,438,256	9	0.73	10	0.07	1	<0.01	1	0.02	5	0.16	1	0.02	0	-----	1.39
Sep 2007	205,529,265	9	0.34	10	0.19	1	0.01	2	0.10	6	0.01	1	0.35	0	-----	2.01
Mean*	**303,131,191**	**6.69**	**0.58**	**5.38**	**0.08**	**1.08**	**0.03**	**1.54**	**0.12**	**2.92**	**0.13**	**1.00**	**0.11**	**0.08**	**<0.01**	**1.87**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 23. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Peck Reservoir at site FTPLKBDCA02 during the period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	8,899,939	1	0.67	0	-----	0	-----	2	0.10	4	0.23	0	-----	0	-----	1.14
Jul 2004	50,170,334	5	0.73	0	-----	1	0.02	2	0.15	2	<0.01	2	0.10	0	-----	1.83
Aug 2004	56,170,0417	8	0.77	2	<0.01	0	-----	1	0.08	1	0.14	2	0.01	0	-----	1.68
Sep 2004	259,164,480	4	0.83	4	0.01	1	<0.01	2	0.06	3	0.02	2	0.08	0	-----	1.33
Jun 2005	135,109,593	1	0 31	2	0.02	1	0.64	2	0.01	1	0.02	0	-----	0	-----	0.88
Jul 2005	60,324,919	5	0.47	1	0.03	0	-----	1	0.43	3	0.08	0	-----	0	-----	1.59
Aug 2005	155,331,963	7	0.41	5	0.10	1	0.03	0	-----	5	0.30	1	0.16	0	-----	2.22
Sep 2005	95,486,617	7	0.60	9	0.06	0	-----	2	0.10	5	0.16	1	0.09	0	-----	2.17
Jun 2006	91,137,918	8	0 91	3	0.01	0	-----	1	<0.01	2	0.02	0	-----	2	0.06	0.89
Jul 2006	73,204,385	6	0.11	5	0.07	0	-----	1	0.04	2	0.67	0	-----	2	0.11	1.48
Aug 2006	86,290,748	5	0.60	4	0.05	0	-----	1	0.14	2	0.21	0	-----	0	-----	1.81
Oct 2006	105,358,293	4	0.65	5	0.01	0	-----	1	0.12	2	0.21	1	<0.01	0	-----	1.58
Jun 2007	361,946,003	7	0.72	5	<0.01	1	0.06	1	0.20	1	<0.01	1	0.01	0	----	1.45
Jul 2007	197,258,569	8	0.06	2	0.01	1	0.14	1	0.06	3	0.48	2	0.26	0	-----	1.74
Mean*	**160,098,870**	**5.43**	**0 56**	**3.36**	**0.03**	**0.43**	**0.15**	**1 29**	**0.11**	**2.57**	**0.18**	**0.86**	**0.09**	**0.29**	**0.09**	**1.56**

* Mean percent composition represents the mean when taxa of that division are present.

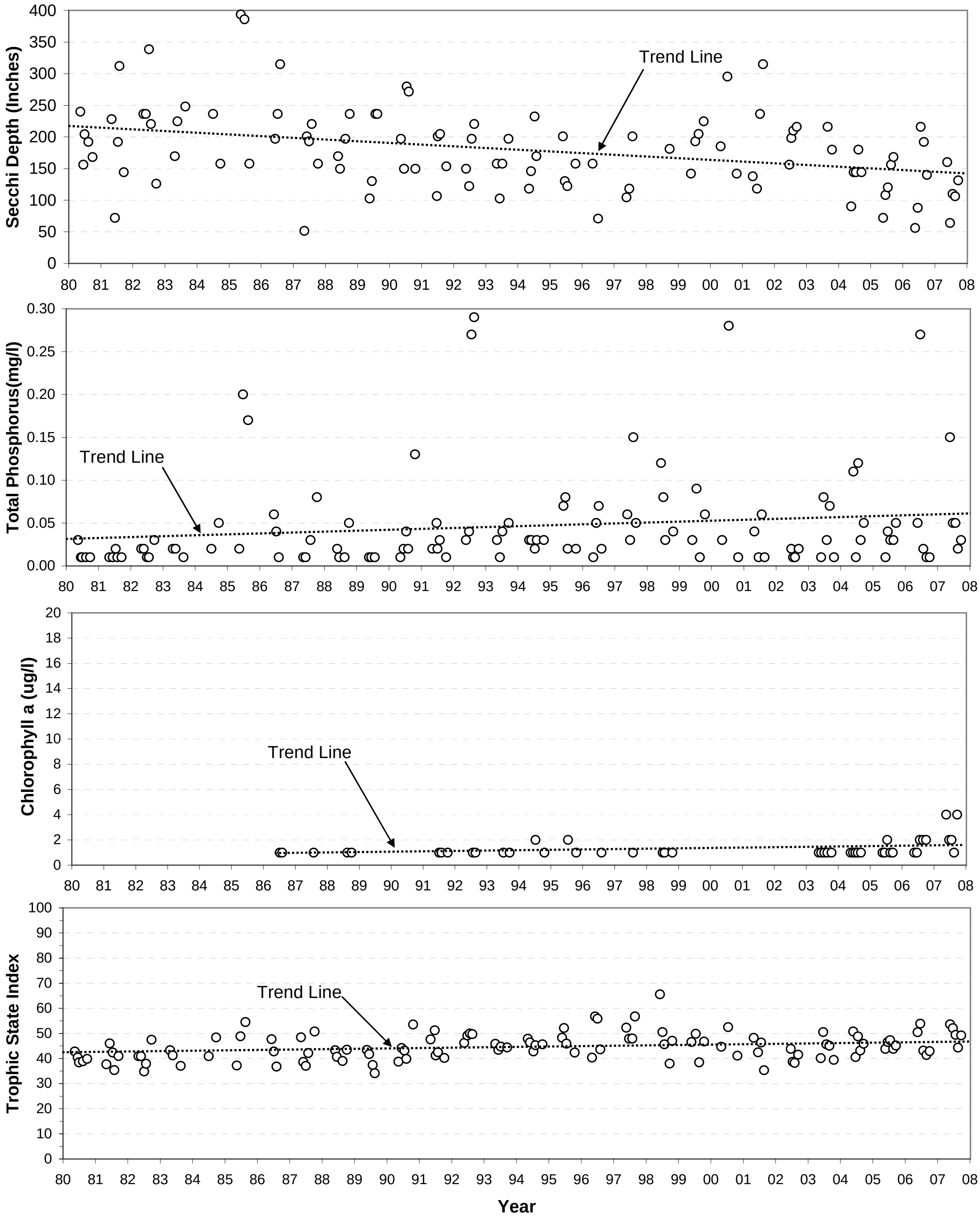


Plate 24. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Fort Peck Reservoir at the near-dam, ambient site (i.e., site FTPLK1772A) over the 28-year period of 1980 to 2007.

Plate 25. Summary of monthly (April through September) water quality conditions monitored in the Missouri River near Landusky, Montana at monitoring Station FTPNFMORR1 during the period 2004 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	1	17	7,286	7,210	4,760	12,200	-----	-----	-----
Water Temperature (C)	0.1	17	18.0	18.1	11.1	26.4	26.7[(1)]	0	0%
Dissolved Oxygen (mg/l)	0.1	17	8.4	8.3	7.0	10.5	≥ 5.0[(2)] ≥ 3.0[(2)]	0 0	0% 0%
Dissolved Oxygen (% Sat.)	0.1	17	91.4	90.3	81.2	101.0	-----	-----	-----
pH (S.U.)	0.1	17	8.4	8.4	8.0	8.9	≥6.5 & ≤9.0	0	0%
Specific Conductance (umho/cm)	1	17	470	449	342	696	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	17	350	345	266	436	-----	-----	-----
Turbidity (NTU)	0.1	17	519	97.3	1.1	3,000	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	5	8	6	2	20	-----	-----	-----
Alkalinity, Total (mg/l)	7	17	147	144	120	175	-----	-----	-----
Ammonia, Total (mg/l)	0.01	17	-----	0.09	n.d.	0.46	2.59 [(3,4)], 0.96 [(3,5)]	0	0%
Carbon, Total Organic (mg/l)	0.05	16	2.8	2.7	1.5	4.2	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	10	30	12	4	171	-----	-----	-----
Chloride, Dissolved (mg/l)	1	9	8	8	6	11	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	16	337	315	255	509	-----	-----	-----
Hardness, Total (mg/l)	0.4	1	171	171	171	171	-----	-----	-----
Iron, Dissolved (ug/l)	40	14	-----	n.d.	n.d.	230	-----	-----	-----
Iron, Total (ug/l)	40	14	17,625	3,209	684	145,000	1,000[(5)], 300[(7)]	14, 14	100%, 100%
Kjeldahl N, Total (mg/l)	0.1	17	1.1	0.5	0.2	5.9	-----	-----	-----
Manganese, Dissolved (ug/l)	1	13	6	4	n.d.	20	-----	-----	-----
Manganese, Total (ug/l)	1	14	206	66	21	1,460	50[(7)]	14	100%
Nitrate-Nitrite N, Total (mg/l)	0.02	17	-----	0.03	n.d.	0.20	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.02	16	-----	0.02	n.d.	0.07	-----	-----	-----
Phosphorus, Total (mg/l)	0.02	17	0.55	0.15	0.03	4.70	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.02	17	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	17	101	83	51	229	-----	-----	-----
Suspended Solids, Total (mg/l)	4	17	770	134	19	7,437	-----	-----	-----
Aluminum, Dissolved (ug/l)	25	1	-----	n.d.	n.d.	n.d.	750[(4)], 87[(5)]	0	0%
Antimony, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	5.6[(6)]	0	0%
Arsenic, Dissolved (ug/l)	1	1	13	13	13	13	340[(4)], 150[(5)], 10[(6)]	0	0%
Barium, Dissolved (ug/l)	5	1	54	54	54	54	2,000[(6)]	0	0%
Beryllium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	4[(6)]	0	0%
Cadmium, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	3.7[(4)], 0.5[(5)], 5[(6)]	0	0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	2,798[(4)], 138[(5)], 100[(6)]	0	0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	23.2[(4)], 14.6[(5)], 1,300[(6)]	0	0%
Lead, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	162[(4)], 6.3[(5)], 15[(6)]	0	0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.7[(4)], 0.91[(5)], 0.05[(6)]	0	0%
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.7[(4)], 0.91[(5)], 0.05[(6)]	0	0%
Nickel, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	739[(4)], 82[(5)], 100[(6)]	0	0%
Selenium, Total (ug/l)	1	1	-----	n.d.	n.d.	n.d.	20[(4)], 5[(5)], 50[(6)]	0	0%
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	10.2[(4)], 100[(6)]	0	0%
Thallium, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	0.24[(6)]	b.d.	b.d.
Zinc, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	189[(4,5)], 2,000[(6)]	0	0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected. b.d. = Criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Numeric temperature criterion given in Montana water quality standards for a B-3 aquatic life use is 26.7 C (80 F).

(2) Dissolved oxygen criteria for B-3 aquatic life use are: 6.0 mg/l (7-Day Mean for Early Life Stages), 5.0 mg/l (1-Day Minimum for Early Life Stages), 5.5 mg/l (30-Day Mean for Other Life Stages), 4.0 mg/l (7-Day Mean Minimum for Other Life Stages), 3.0 mg/l (1-Day Minimum for Other Life Stages). Early life stages are all embryonic and larval stages and all juvenile fish to 30 days following hatching.

(3) Total ammonia criteria pH and temperature dependent – criteria listed are for the median pH and temperature values.

(4) Acute criterion for aquatic life.

(5) Chronic criterion for aquatic life.

(6) Human health criterion for surface waters.

(7) Secondary Maximum Contaminant Level based on aesthetic properties.

Note: Montana's criteria for metals are based on total recoverable, most metals were analyzed for dissolved. Listed criteria are given for comparison and were calculated using the median hardness value.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides do not have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

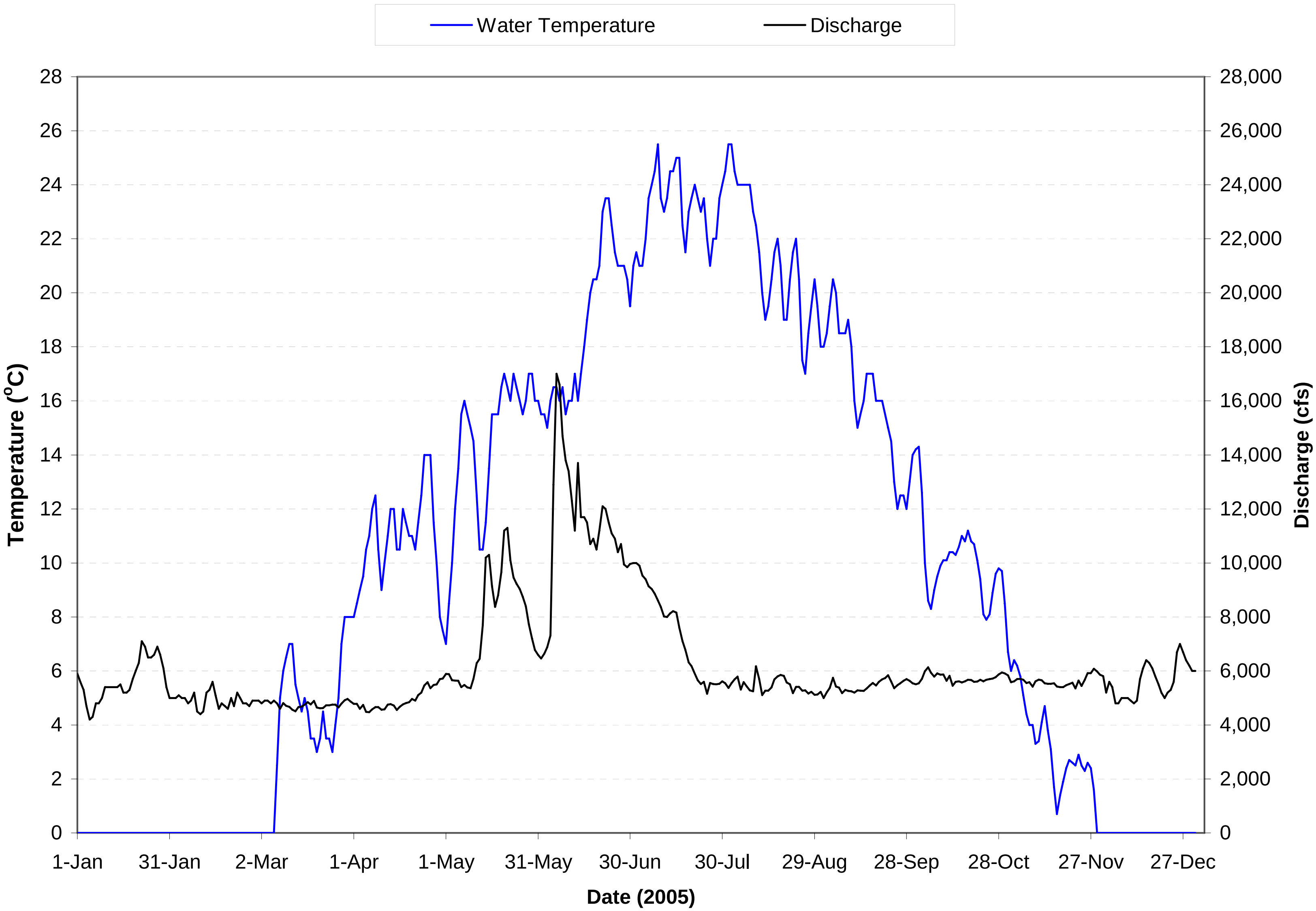


Plate 26. Mean daily water temperature and discharge of the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1) for 2005. Means based on hourly measurements recorded at USGS gaging station 06115200.

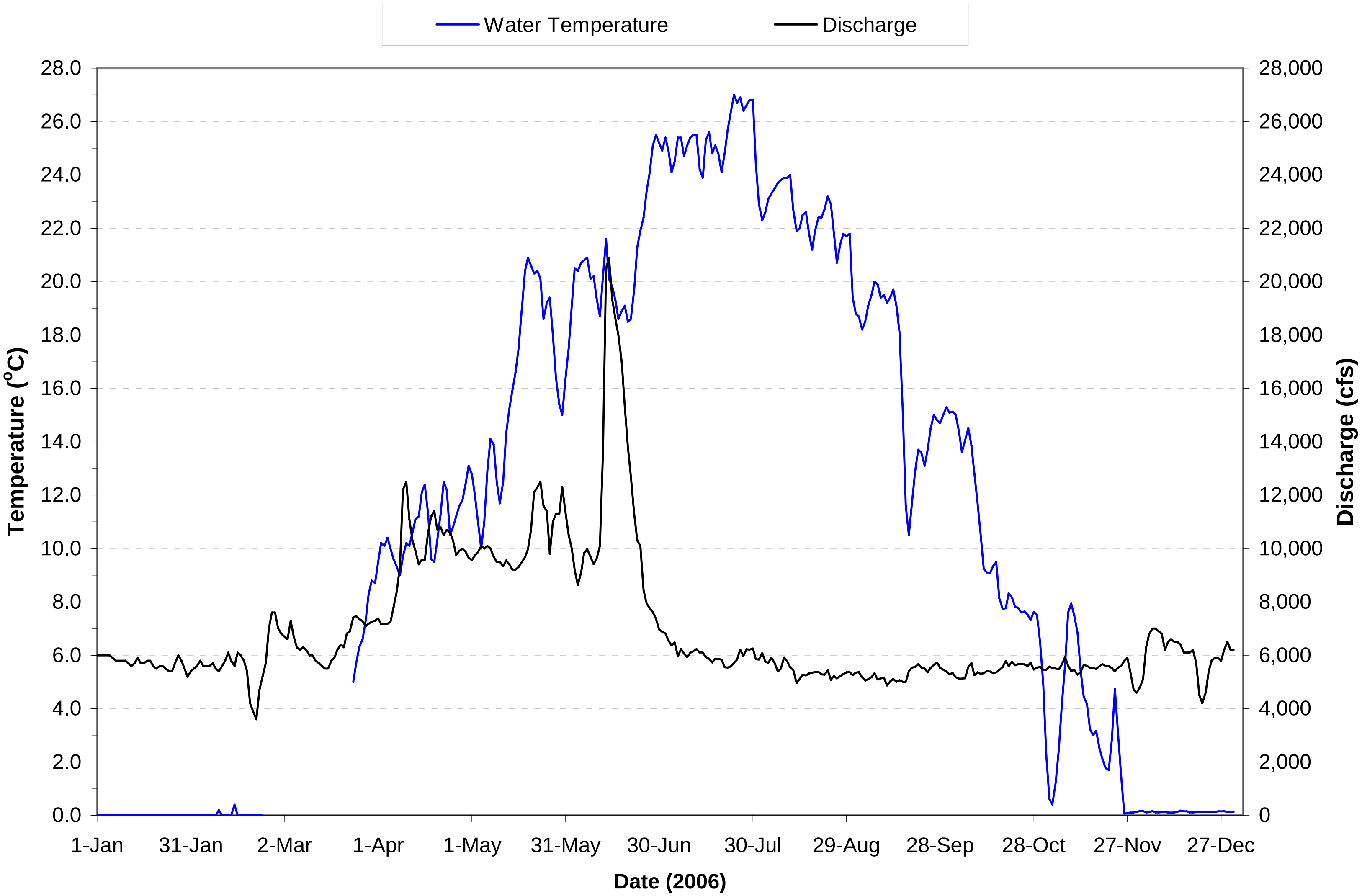


Plate 27. Mean daily water temperature and discharge of the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1) for 2006. Means based on hourly measurements recorded at USGS gaging station 06115200.

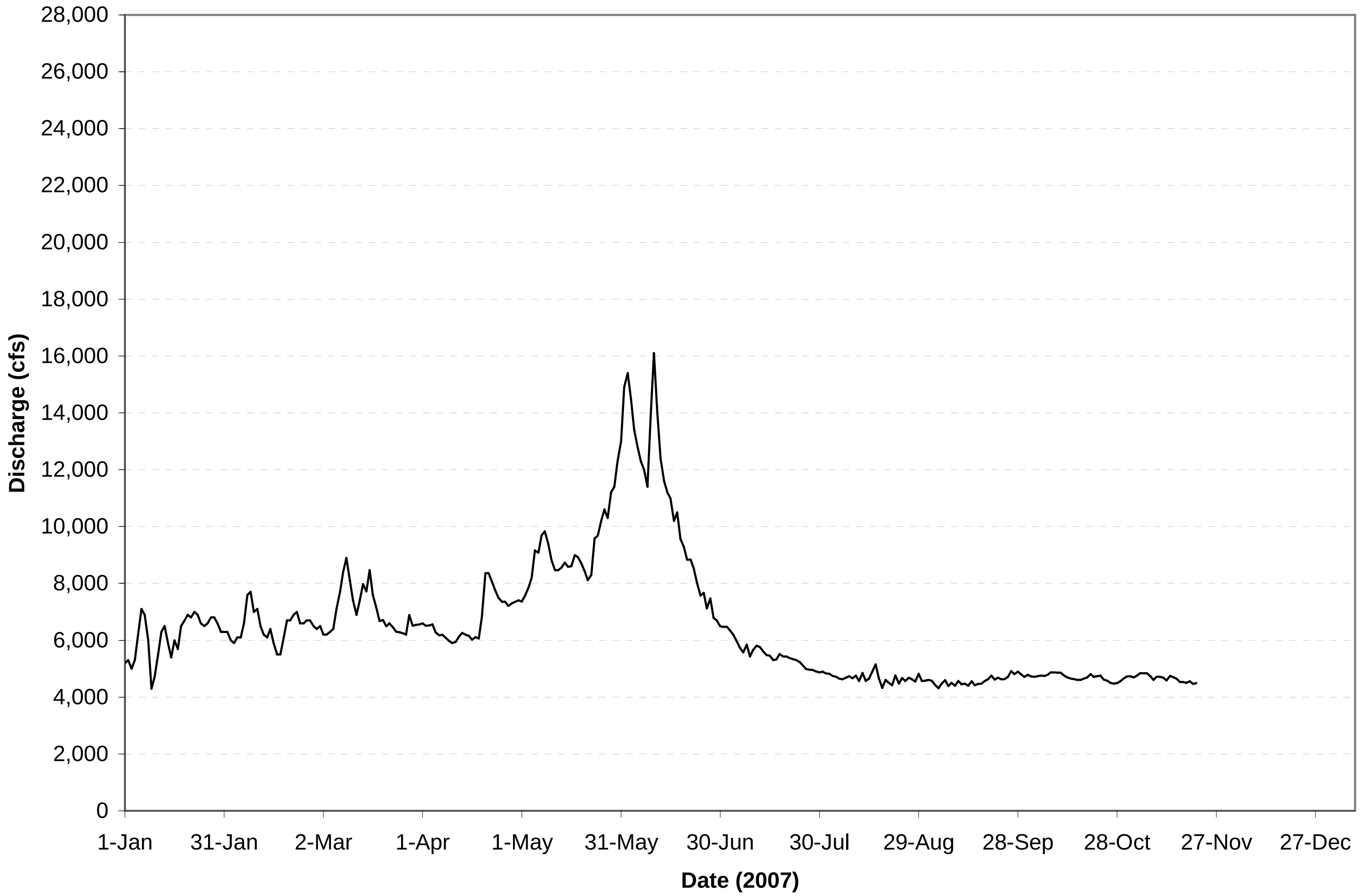


Plate 28. Mean daily discharge of the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1) for 2007. Means based on hourly measurements recorded at USGS gaging station 06115200. (Note: data are provisional.)

Plate 29. Summary of water quality conditions monitored on water discharged through Fort Peck Dam (i.e., site FTPPP1) during the 4-year period of January 2004 through December 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	38	6,949	6,700	3,000	12,513	-----	-----	-----
Water Temperature (C)	0.1	38	9.7	10.4	1.4	17.3	19.4[1]	0	0%
Dissolved Oxygen (mg/l)	0.1	38	9.9	9.6	6.0	13.8	≥ 8.0[2] ≥ 4.0[2]	7 0	18% 0%
Dissolved Oxygen (% Sat.)	0.1	38	90.4	93.2	62.7	103.2	-----	-----	-----
pH (S.U.)	0.1	33	8.2	8.3	7.8	8.7	≥6.5 & ≤9.0	0	0%
Specific Conductance (umho/cm)	1	38	515	520	405	704	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	19	402	412	300	575	-----	-----	-----
Turbidity (NTU)	0.1	16	2.1	1.9	n.d.	6.3	-----	-----	-----
Alkalinity, Total (mg/l)	7	38	161	161	140	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	38	-----	0.02	n.d.	0.51	3.14 [3,4], 1.86 [3,5]	0	0%
Carbon, Total Organic (mg/l)	0.05	37	2.7	2.4	2.1	5.3	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	9	8	n.d.	41	-----	-----	-----
Chloride, Dissolved (mg/l)	1	19	9	9	7	12	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	38	363	350	306	496	-----	-----	-----
Hardness, Total (mg/l)	0.4	4	198	203	174	213	-----	-----	-----
Iron, Dissolved (ug/l)	40	29	-----	n.d.	n.d.	40	-----	-----	-----
Iron, Total (ug/l)	40	30	207	120	n.d.	2,015	1,000[5], 300[7]	1, 3	3%, 10%
Kjeldahl N, Total (mg/l)	0.1	38	0.5	0.3	n.d.	2.2	-----	-----	-----
Manganese, Dissolved (ug/l)	1	29	-----	1	n.d.	10	-----	-----	-----
Manganese, Total (ug/l)	1	29	8	6	n.d.	38	50[7]	0	0%
Nitrate-Nitrite N, Total (mg/l)	0.02	38	-----	n.d.	n.d.	0.11	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.02	29	-----	n.d.	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.02	38	-----	0.03	n.d.	0.14	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.02	38	-----	n.d.	n.d.	0.02	-----	-----	-----
Sulfate (mg/l)	1	38	130	123	57	209	-----	-----	-----
Suspended Solids, Total (mg/l)	4	38	-----	n.d.	n.d.	80	-----	-----	-----
Aluminum, Dissolved (ug/l)	25	2	-----	n.d.	n.d.	n.d.	750[4], 87[5]	0	0%
Antimony, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	0.5	5.6[6]	0	0%
Arsenic, Dissolved (ug/l)	1	5	-----	n.d.	n.d.	4	340[4], 150[5], 10[6]	0	0%
Barium, Dissolved (ug/l)	5	1	42	42	42	42	2,000[6]	0	0%
Beryllium, Dissolved (ug/l)	2	3	-----	n.d.	n.d.	n.d.	4[6]	0	0%
Cadmium, Dissolved (ug/l)	0.2	5	-----	n.d.	n.d.	n.d.	4.4[4], 0.5[5], 5[6]	0	0%
Chromium, Dissolved (ug/l)	10	5	-----	n.d.	n.d.	n.d.	3,220[4], 154[5], 100[6]	0	0%
Copper, Dissolved (ug/l)	2	5	-----	3	n.d.	4	27.3[4], 17.1[5], 1,300[6]	0	0%
Lead, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	n.d.	201[4], 7.8[5], 15[6]	0	0%
Mercury, Dissolved (ug/l)	0.02	6	-----	n.d.	n.d.	n.d.	1.7[4], 0.91[5], 0.05[6]	0	0%
Mercury, Total (ug/l)	0.02	6	-----	n.d.	n.d.	n.d.	1.7[4], 0.91[5], 0.05[6]	0	0%
Nickel, Dissolved (ug/l)	10	5	-----	n.d.	n.d.	3	854[4], 95[5], 100[6]	0	0%
Selenium, Total (ug/l)	1	5	-----	n.d.	n.d.	n.d.	20[4], 5[5], 50[6]	0	0%
Silver, Dissolved (ug/l)	1	5	-----	n.d.	n.d.	n.d.	13.7[4], 100[6]	0	0%
Thallium, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	n.d.	0.24[6]	b.d.	b.d.
Zinc, Dissolved (ug/l)	10	5	7	8	4	10	218[4,5], 2,000[6]	0	0%
Pesticide Scan (ug/l)***	0.05	4	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected. b.d. = Criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Numeric temperature criterion given in Montana water quality standards for a B-2 aquatic life use is 19.4 C (67 F).

(2) Dissolved oxygen criteria for B-2 aquatic life use are: 9.5 mg/l (7-Day Mean for Early Life Stages), 8.0 mg/l (1-Day Minimum for Early Life Stages), 6.5 mg/l (30-Day Mean for Other Life Stages), 5.0 mg/l (7-Day Mean Minimum for Other Life Stages), 4.0 mg/l (1-Day Minimum for Other Life Stages). Early life stages are all embryonic and larval stages and all juvenile fish to 30 days following hatching.

(3) Total ammonia criteria pH and temperature dependent – criteria listed are for the median pH and temperature values.

(4) Acute criterion for aquatic life.

(5) Chronic criterion for aquatic life.

(6) Human health criterion for surface waters.

(7) Secondary Maximum Contaminant Level based on aesthetic properties.

Note: Montana's criteria for metals are based on total recoverable, most metals were analyzed for dissolved. Listed criteria are given for comparison and were calculated using the median hardness value.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides do not have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

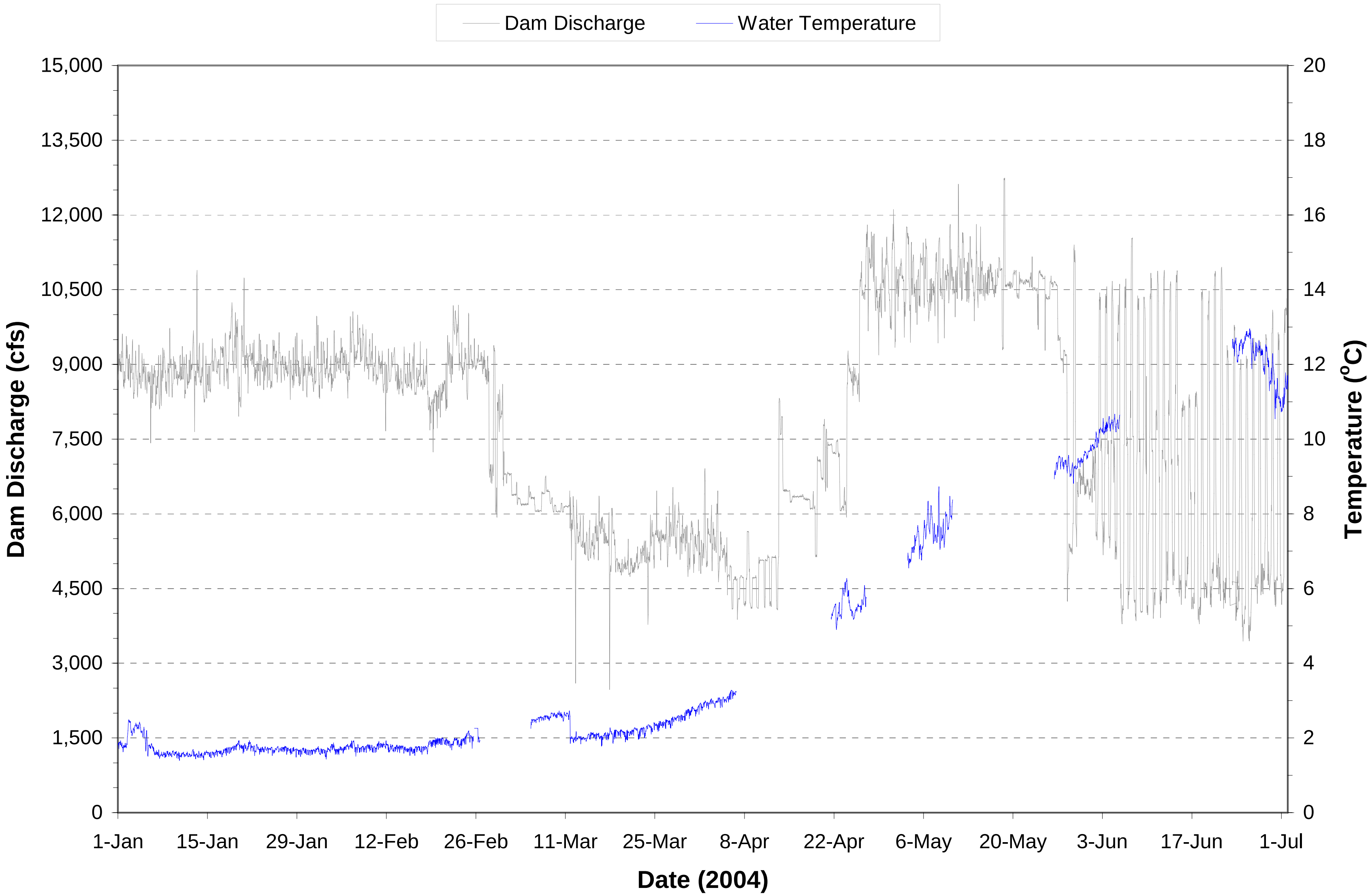


Plate 30. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

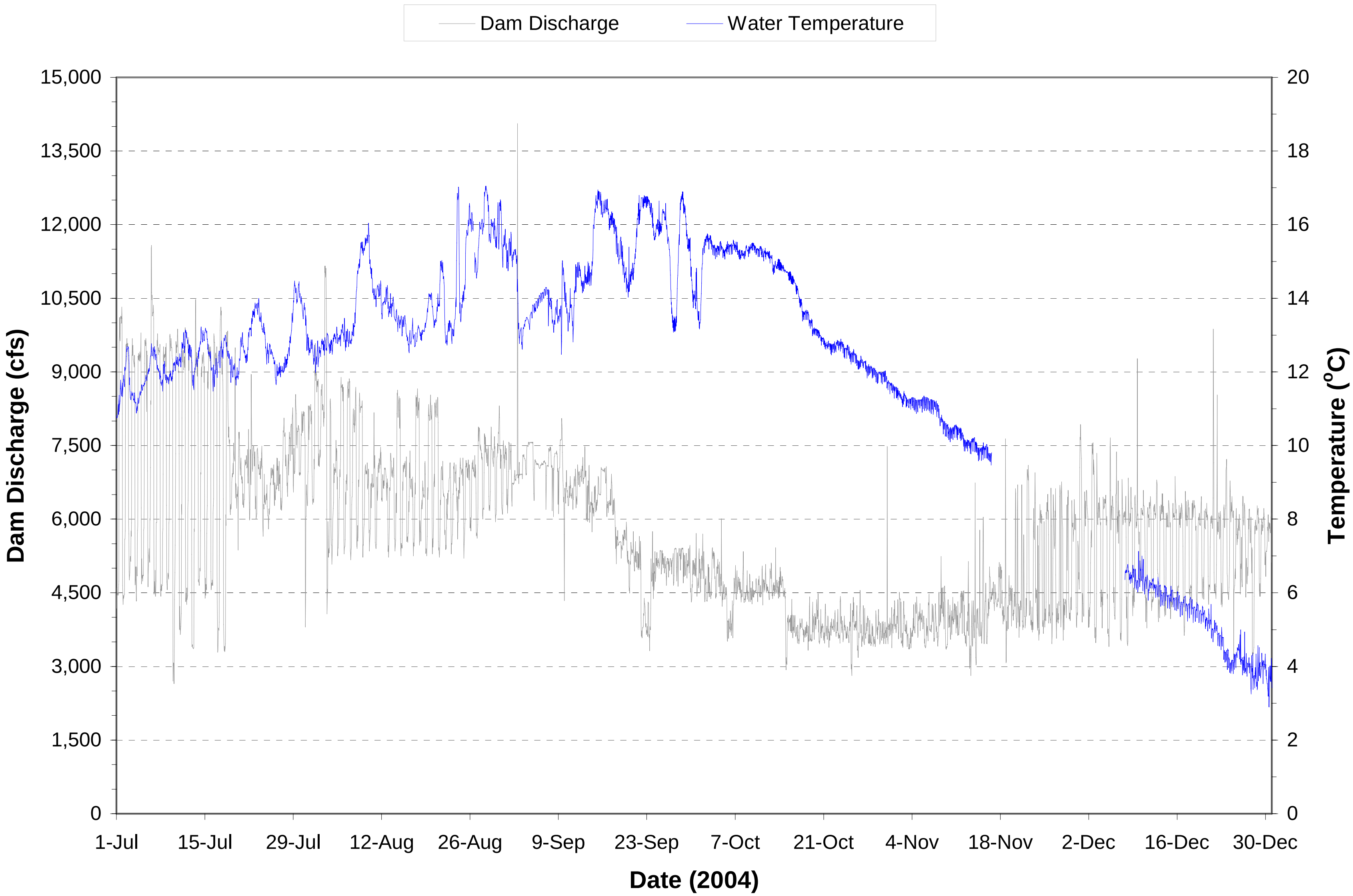


Plate 31. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

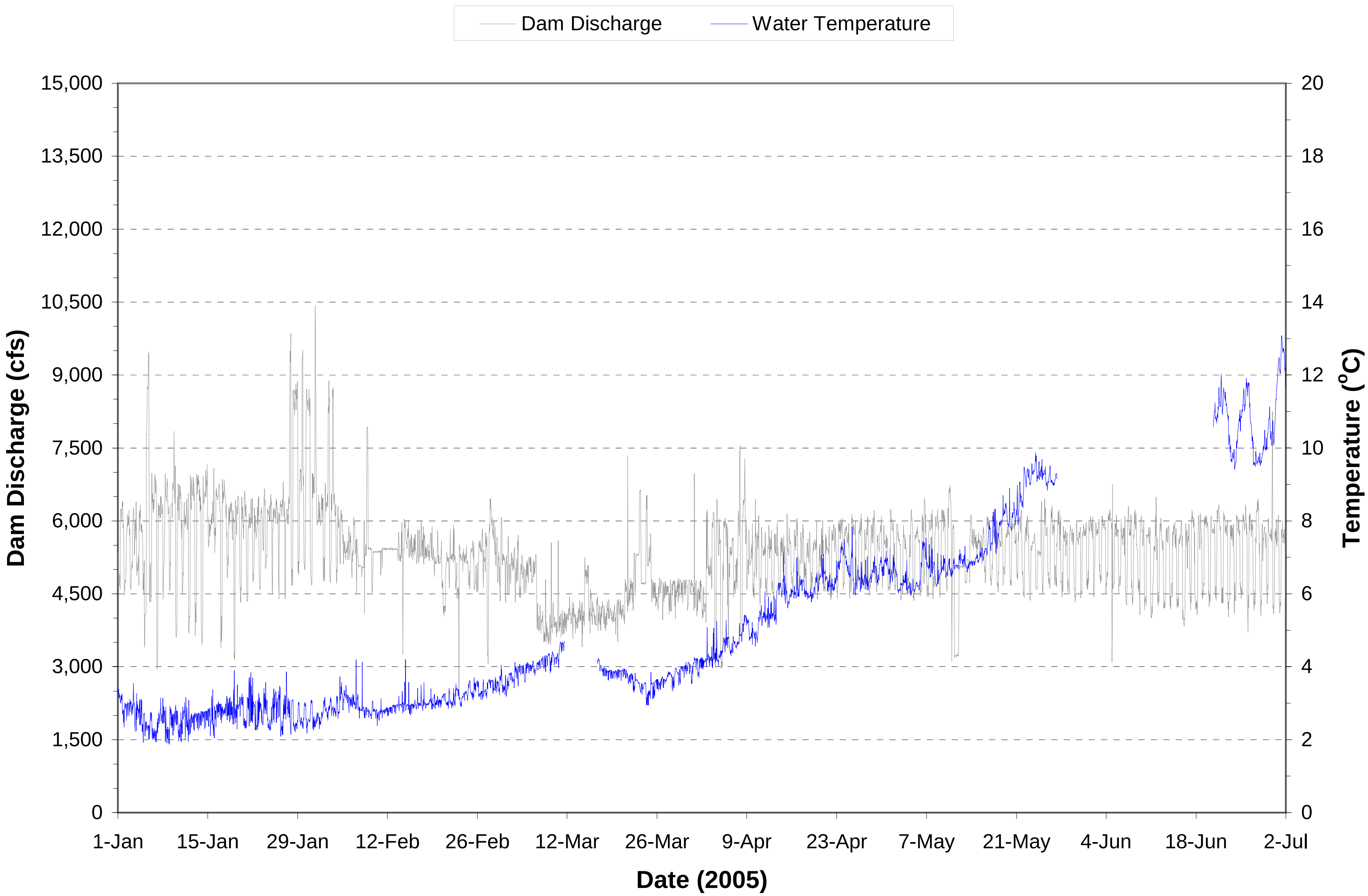


Plate 32. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

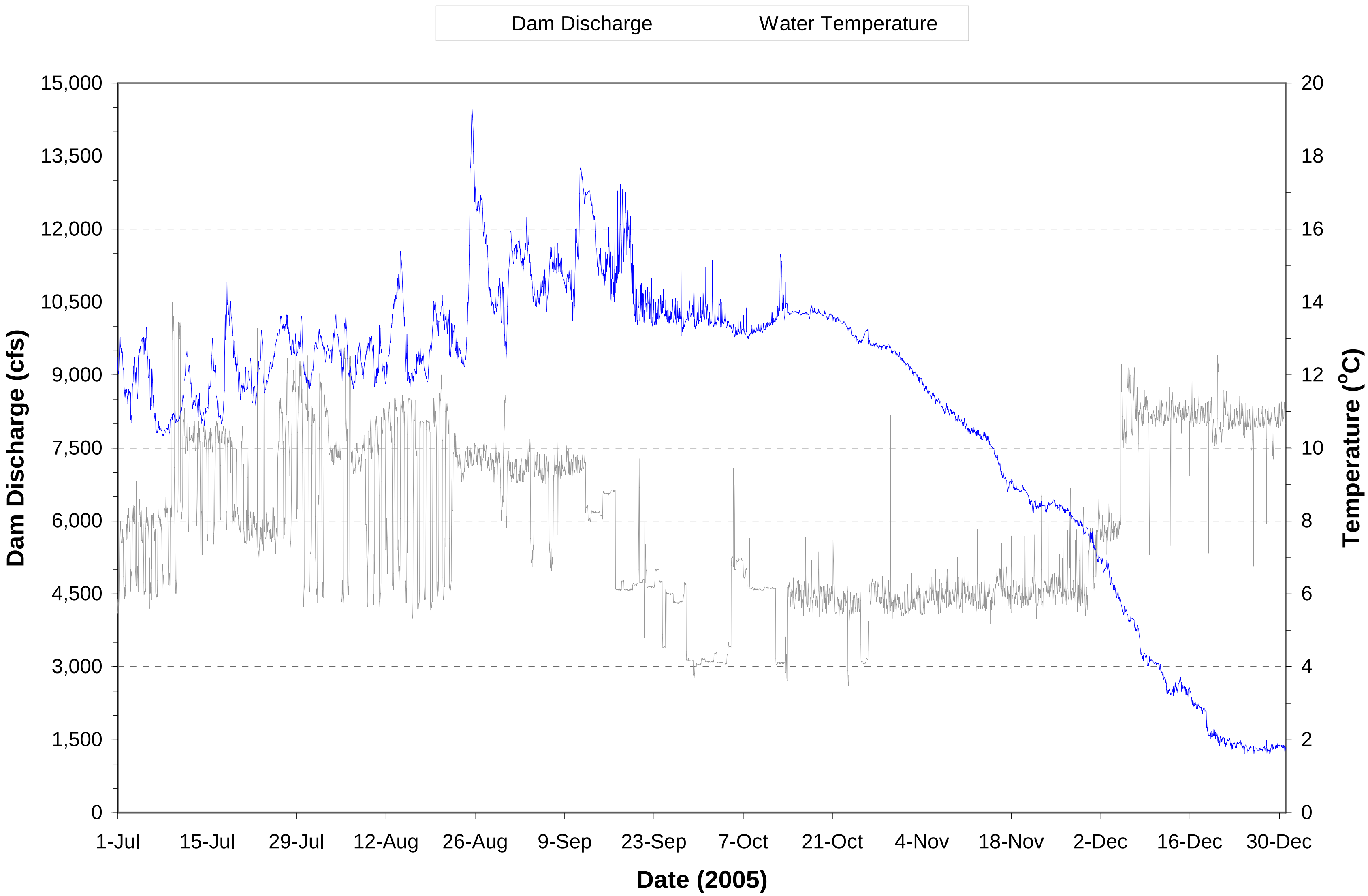


Plate 33. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2005.

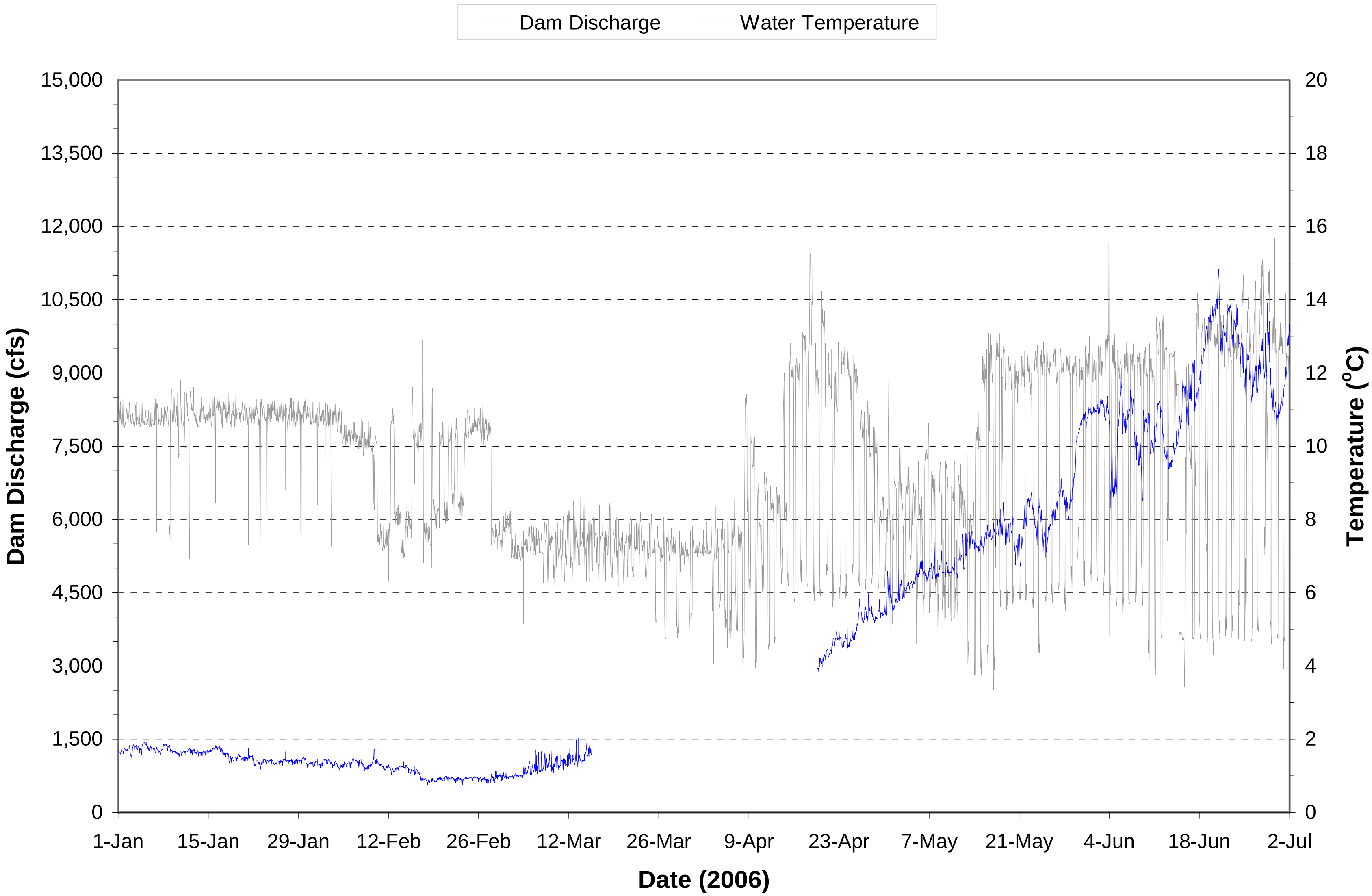


Plate 34. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

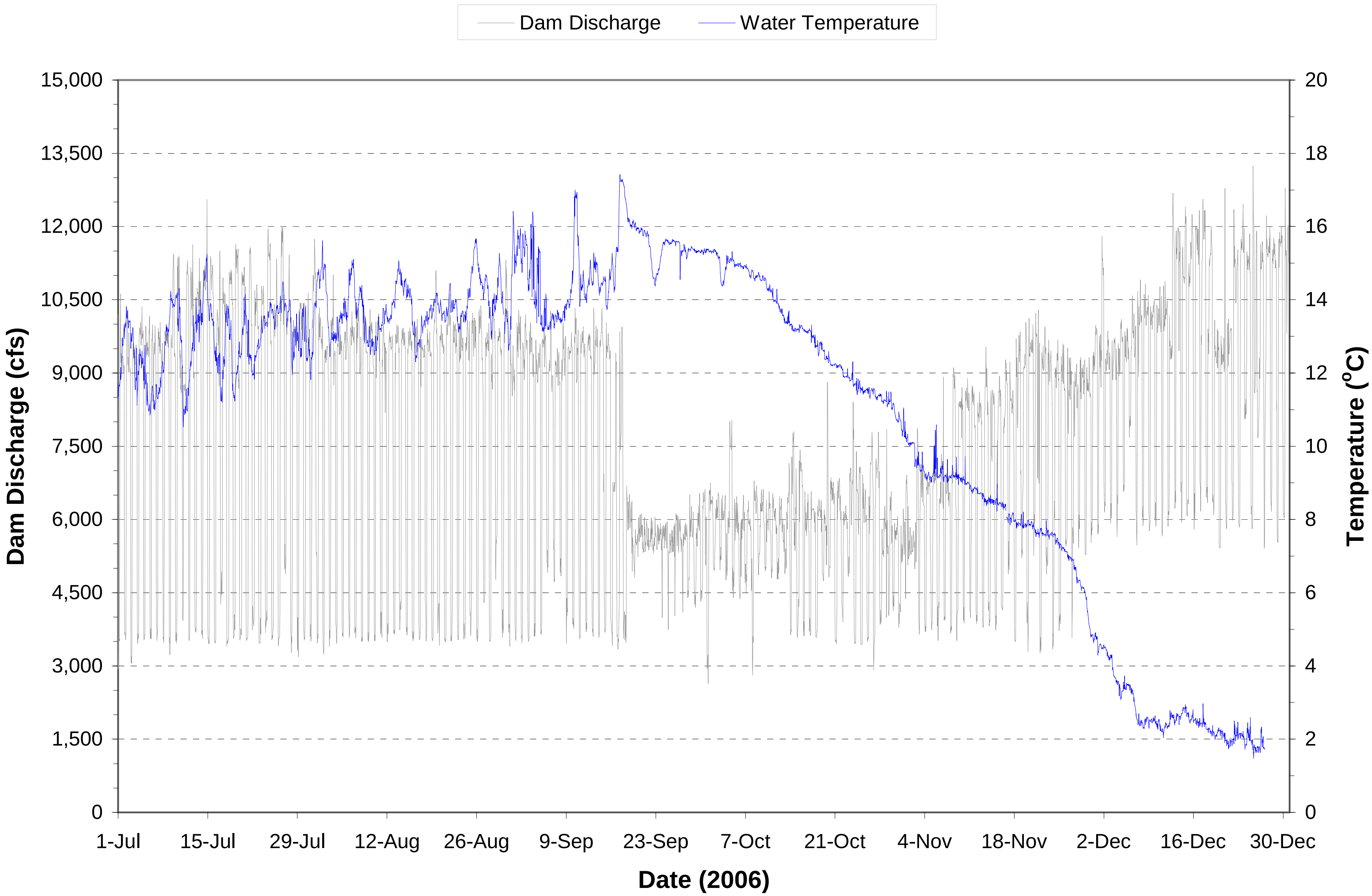


Plate 35. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

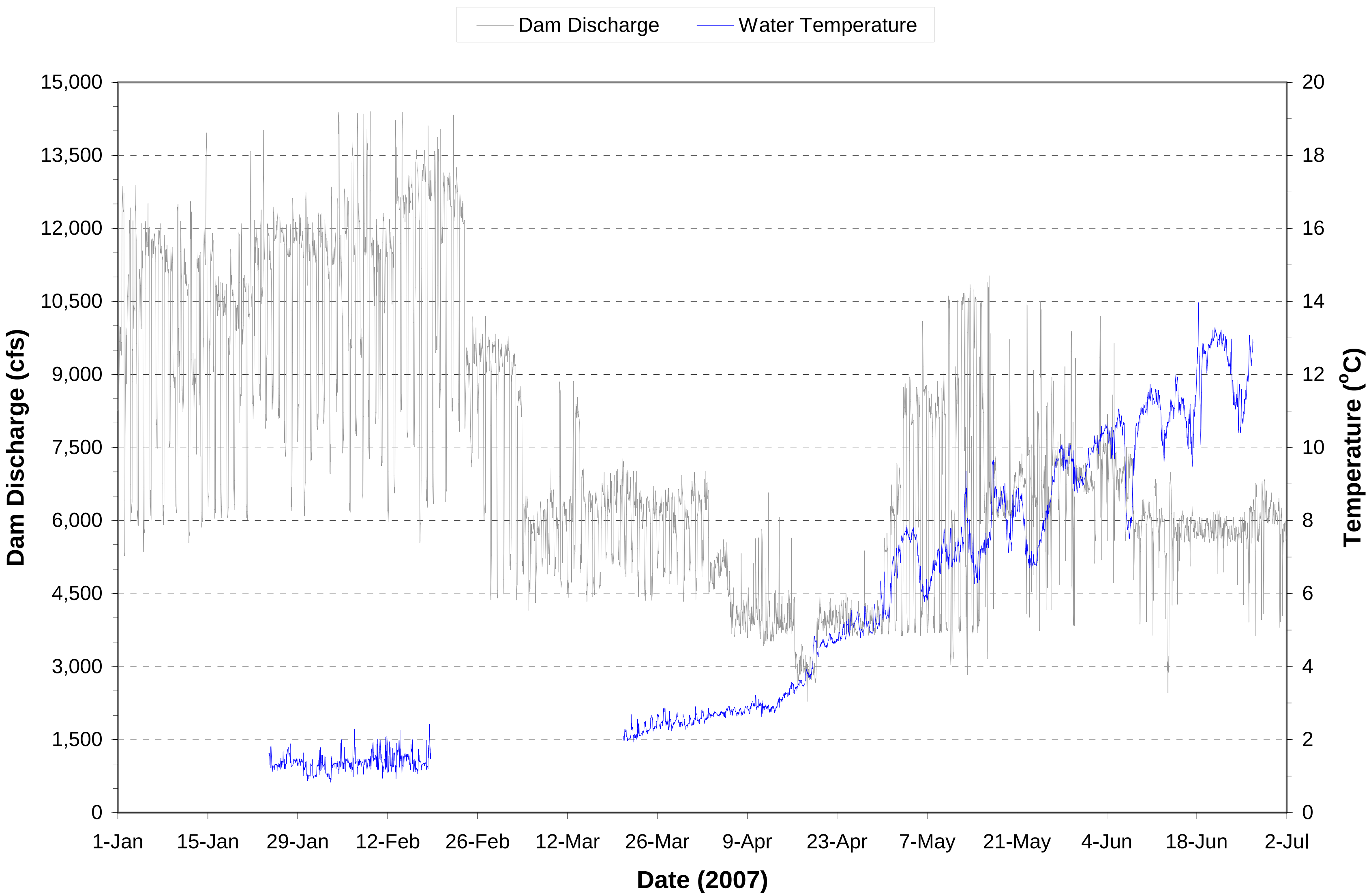


Plate 36. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

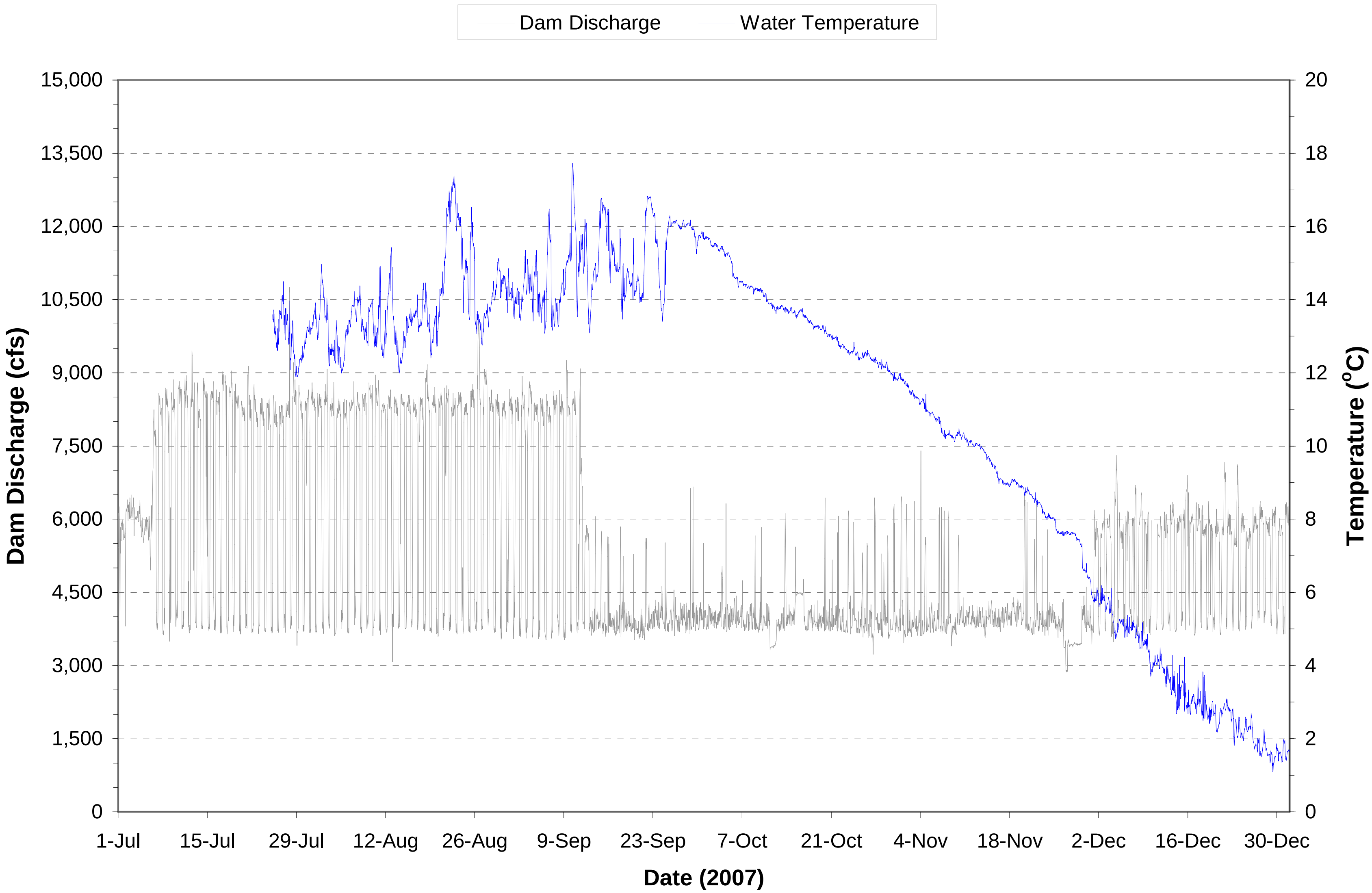


Plate 37. Hourly discharge and water temperature monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

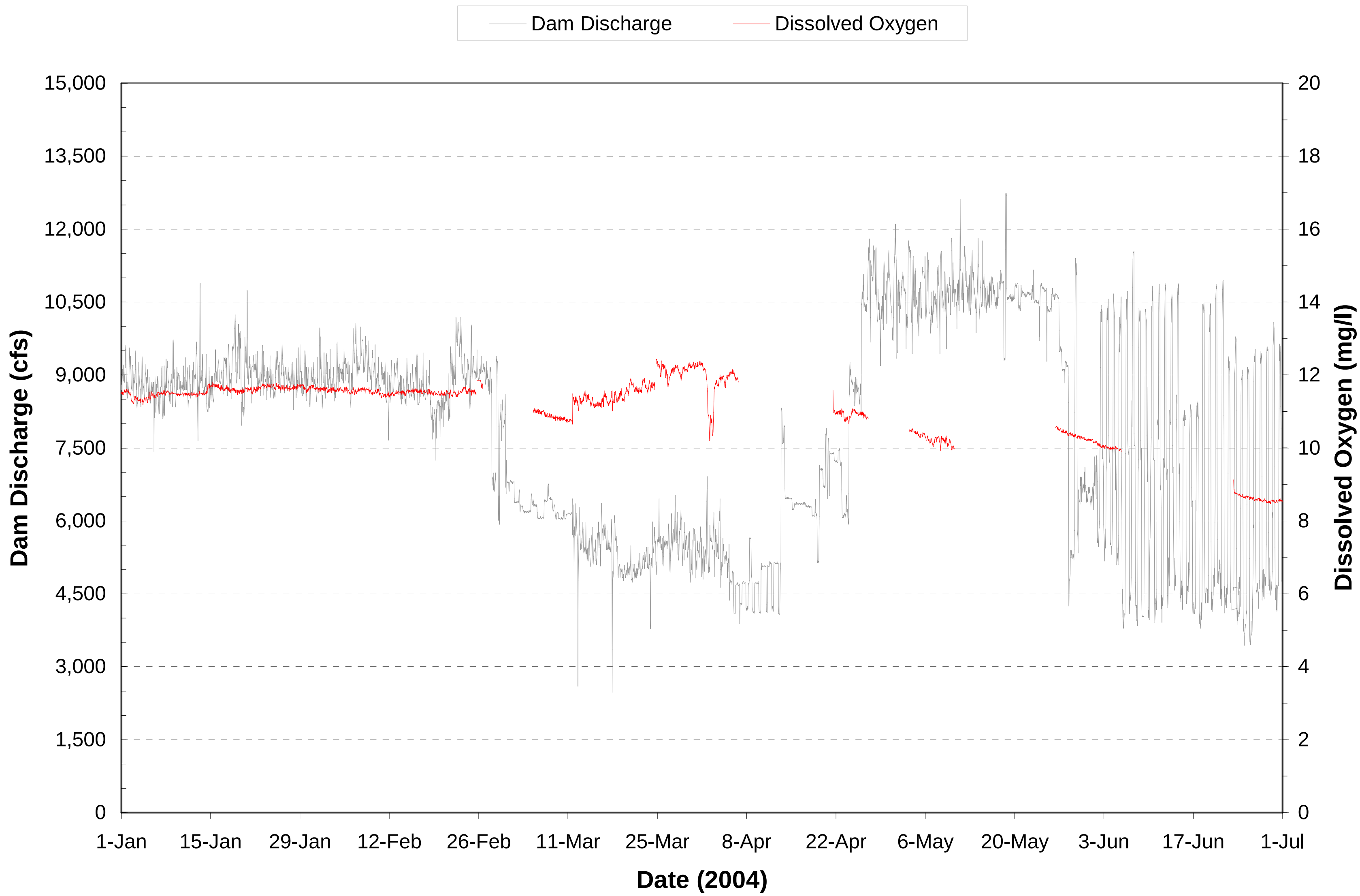


Plate 38. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

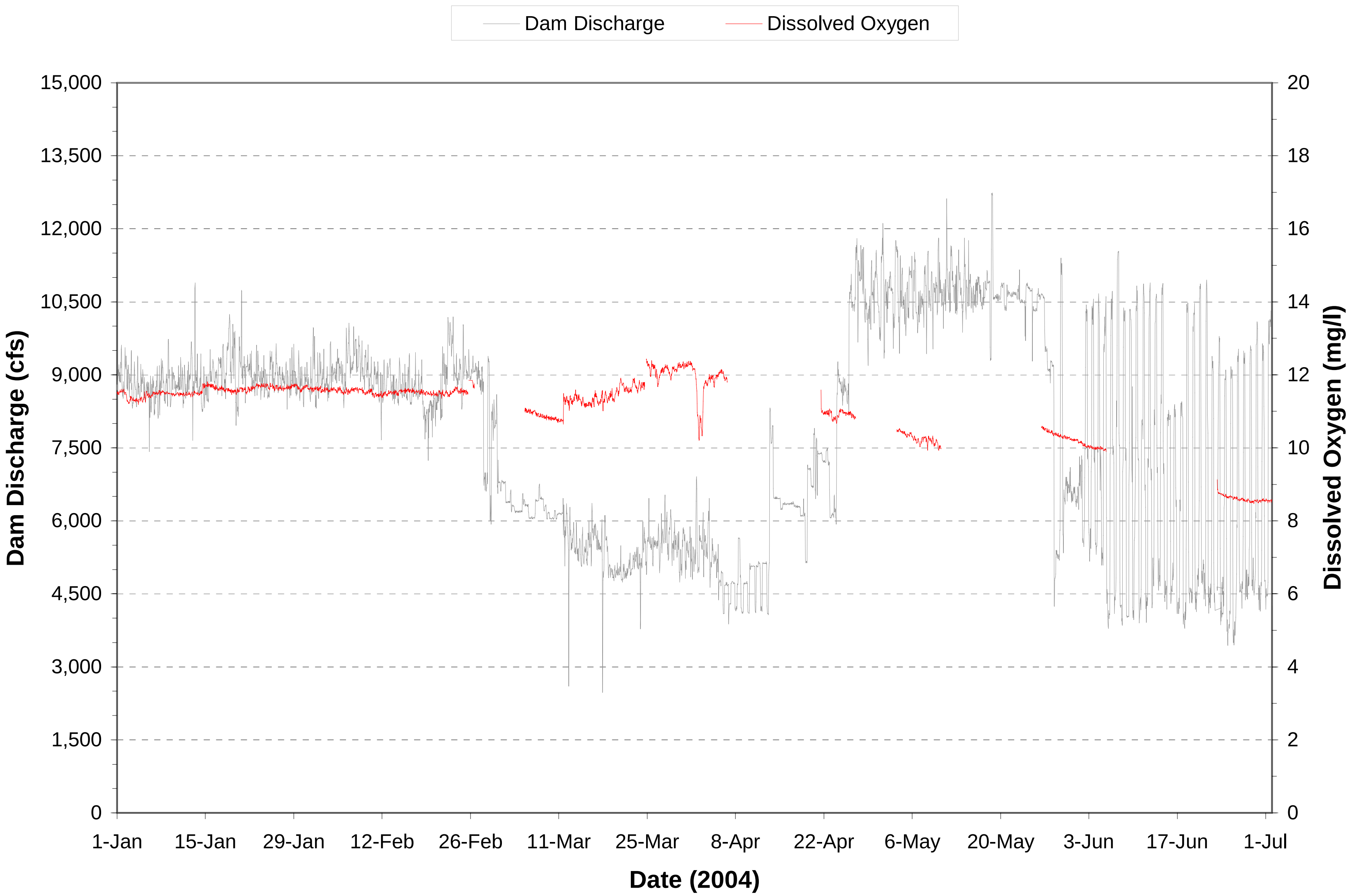


Plate 39. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period July and December 2004. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

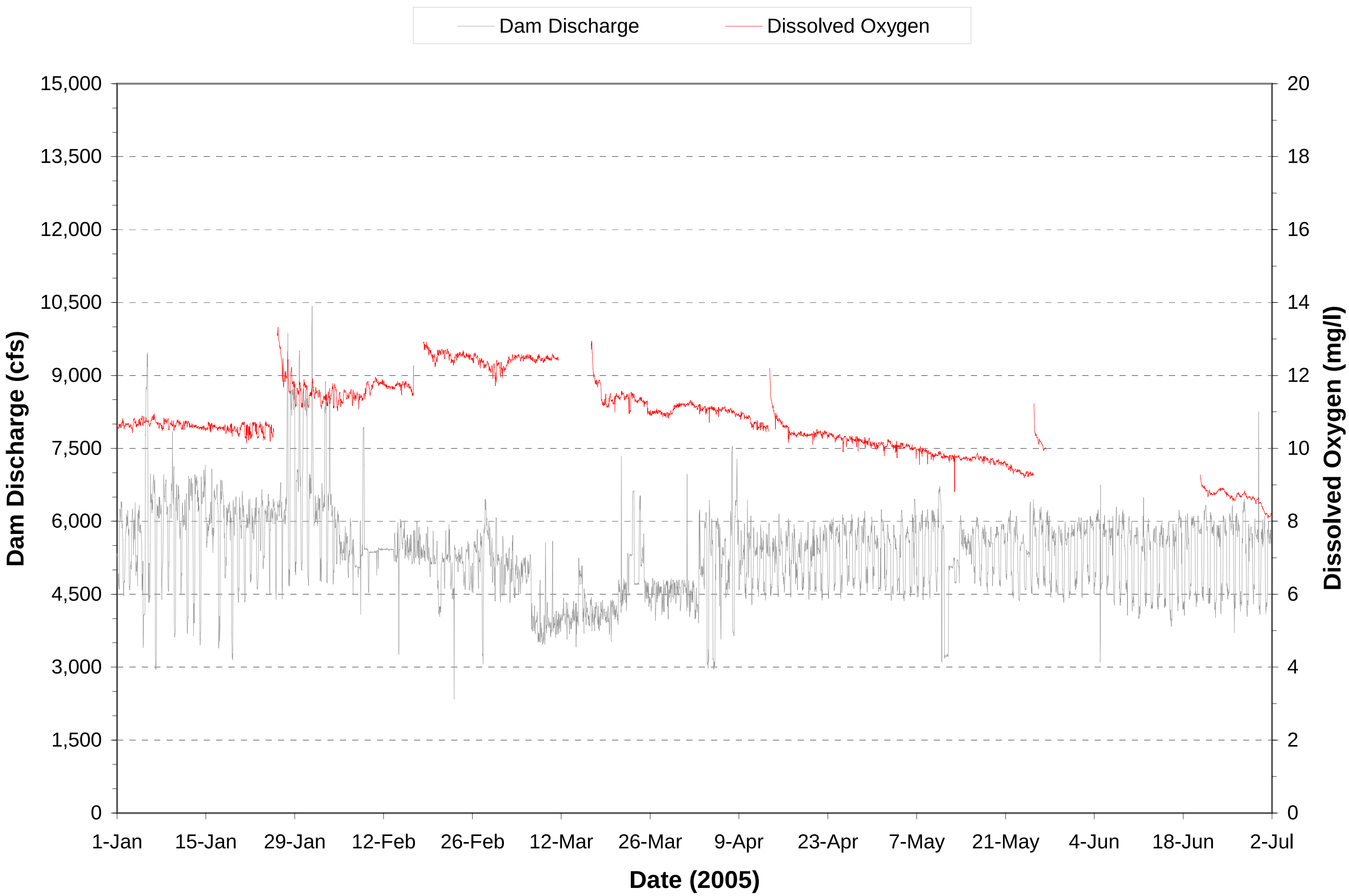


Plate 40. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

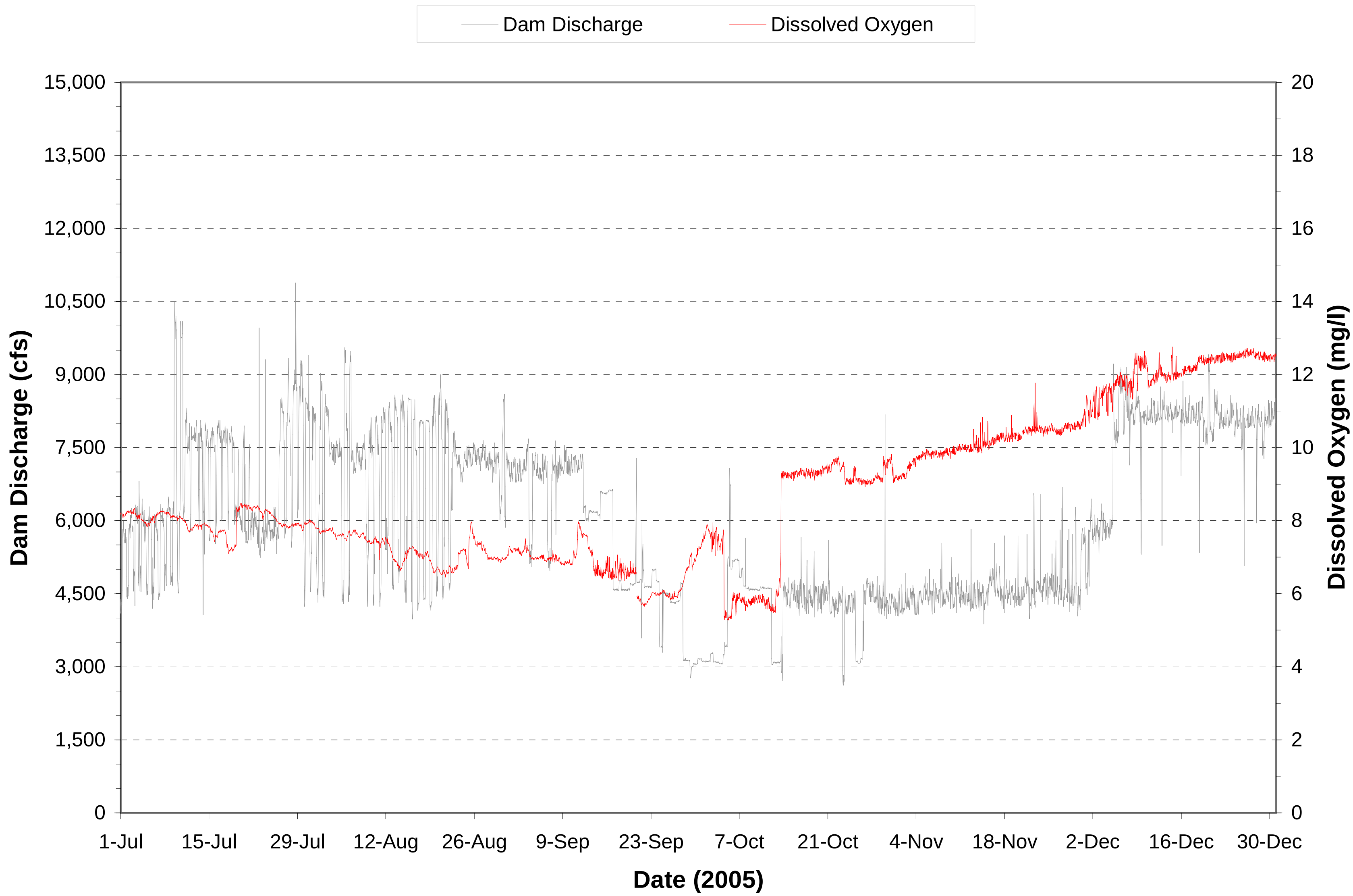


Plate 41. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2005.

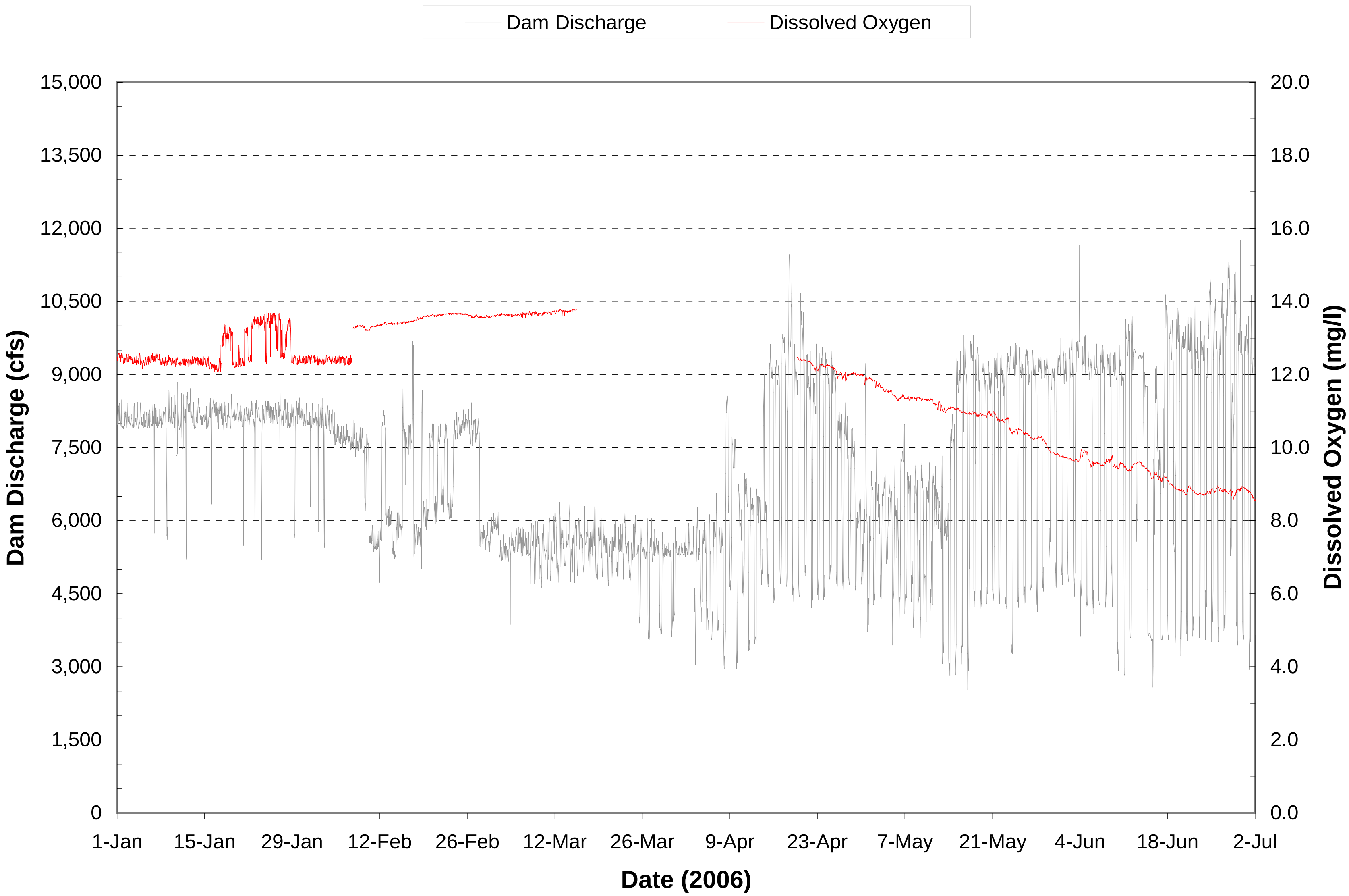


Plate 42. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

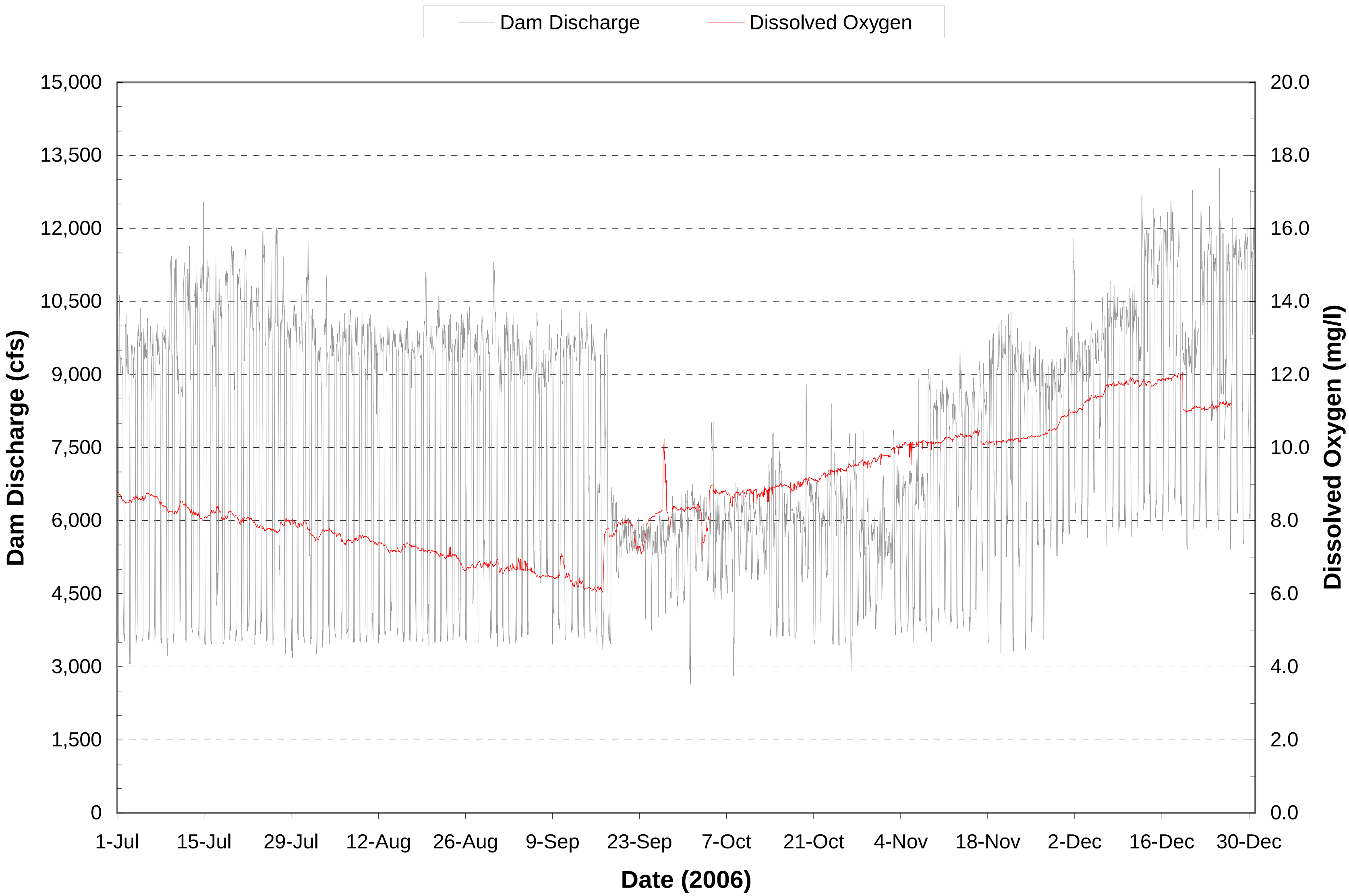


Plate 43. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

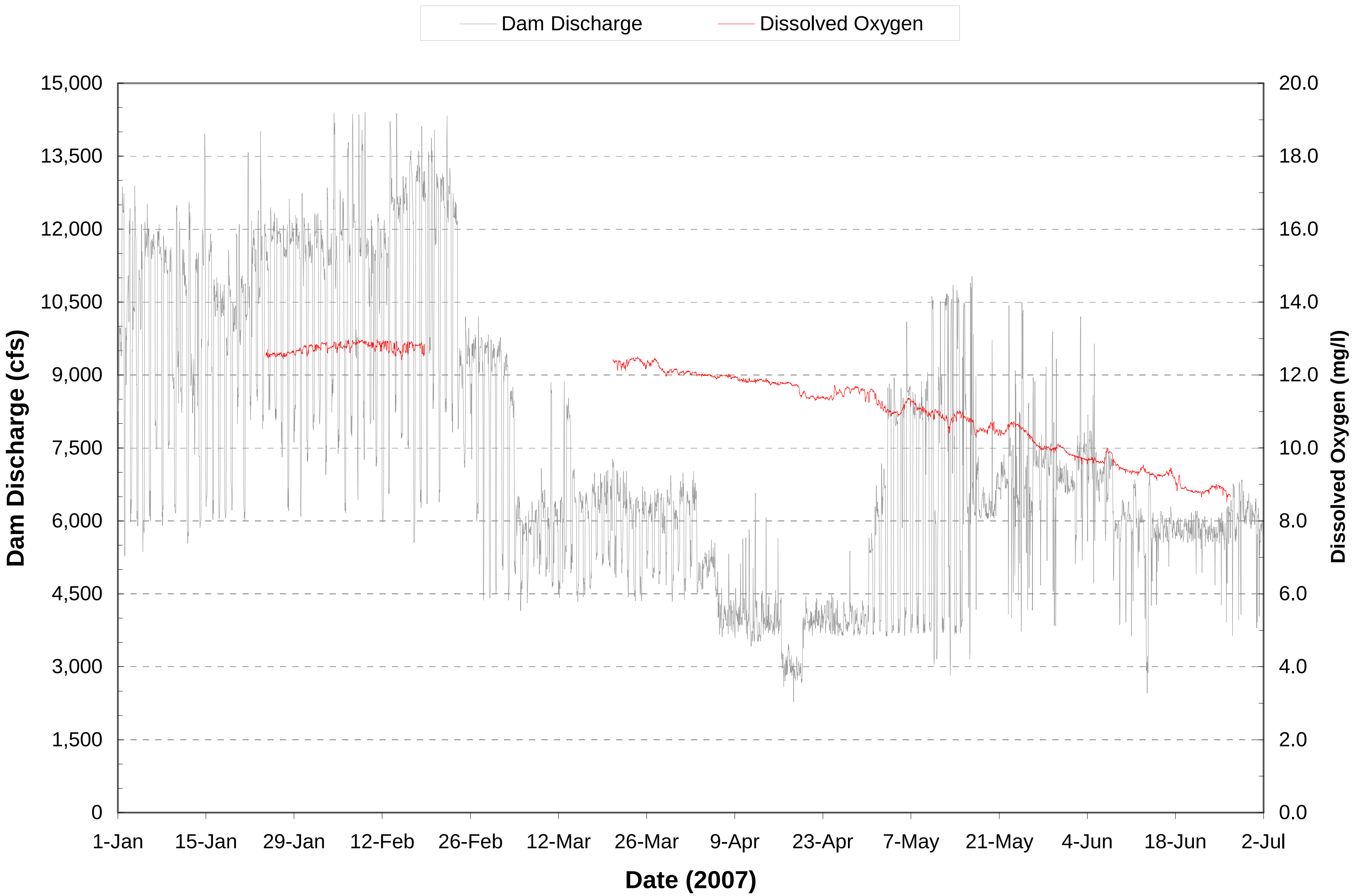


Plate 44. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

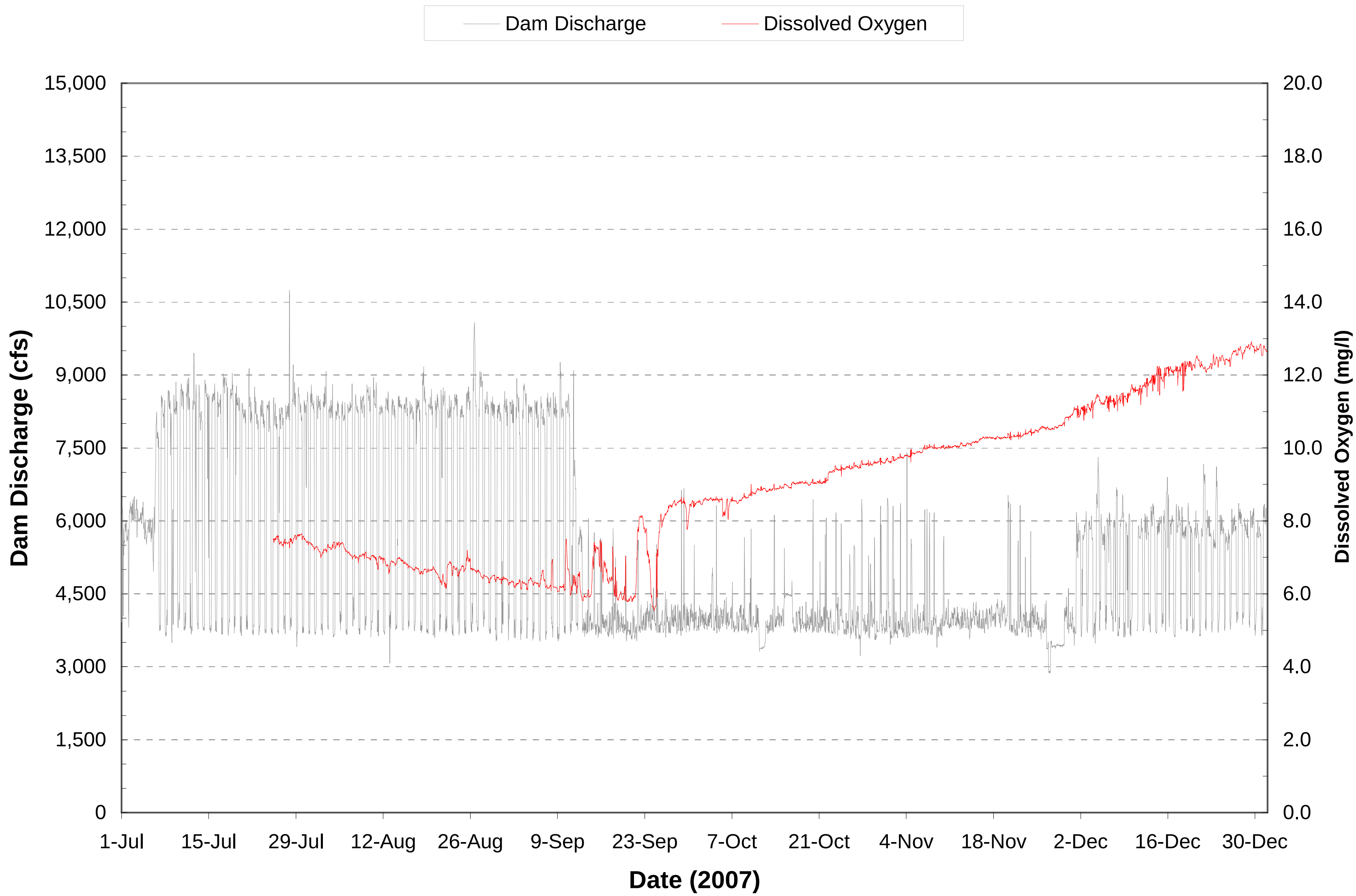


Plate 45. Hourly discharge and dissolved oxygen monitored at the Fort Peck powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in dissolved oxygen plot represent periods when monitoring equipment was not operational.)

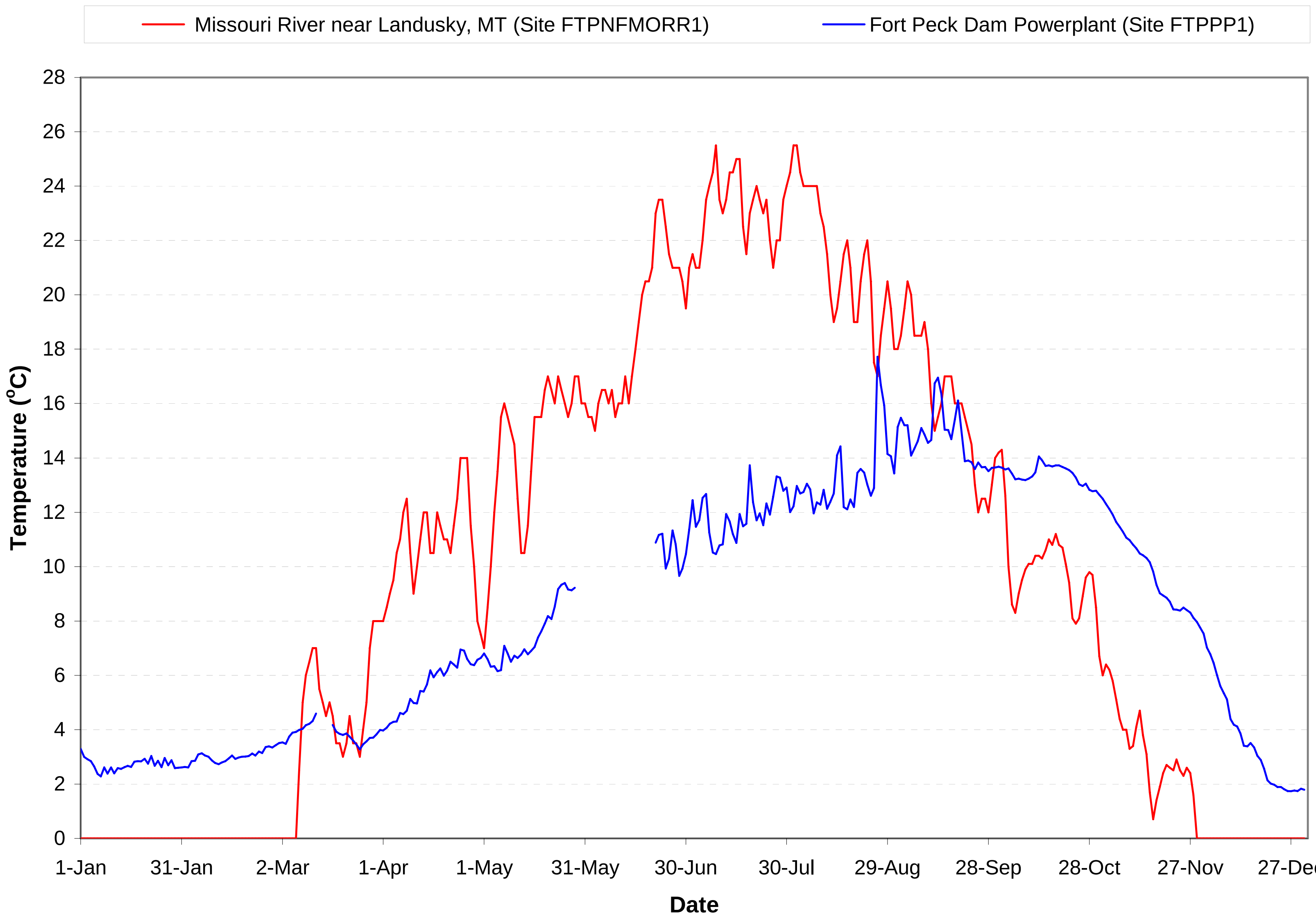


Plate 46. Mean daily water temperatures monitored at the Fort Peck Powerplant (i.e., site FTPPP1) and the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1) during 2005. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

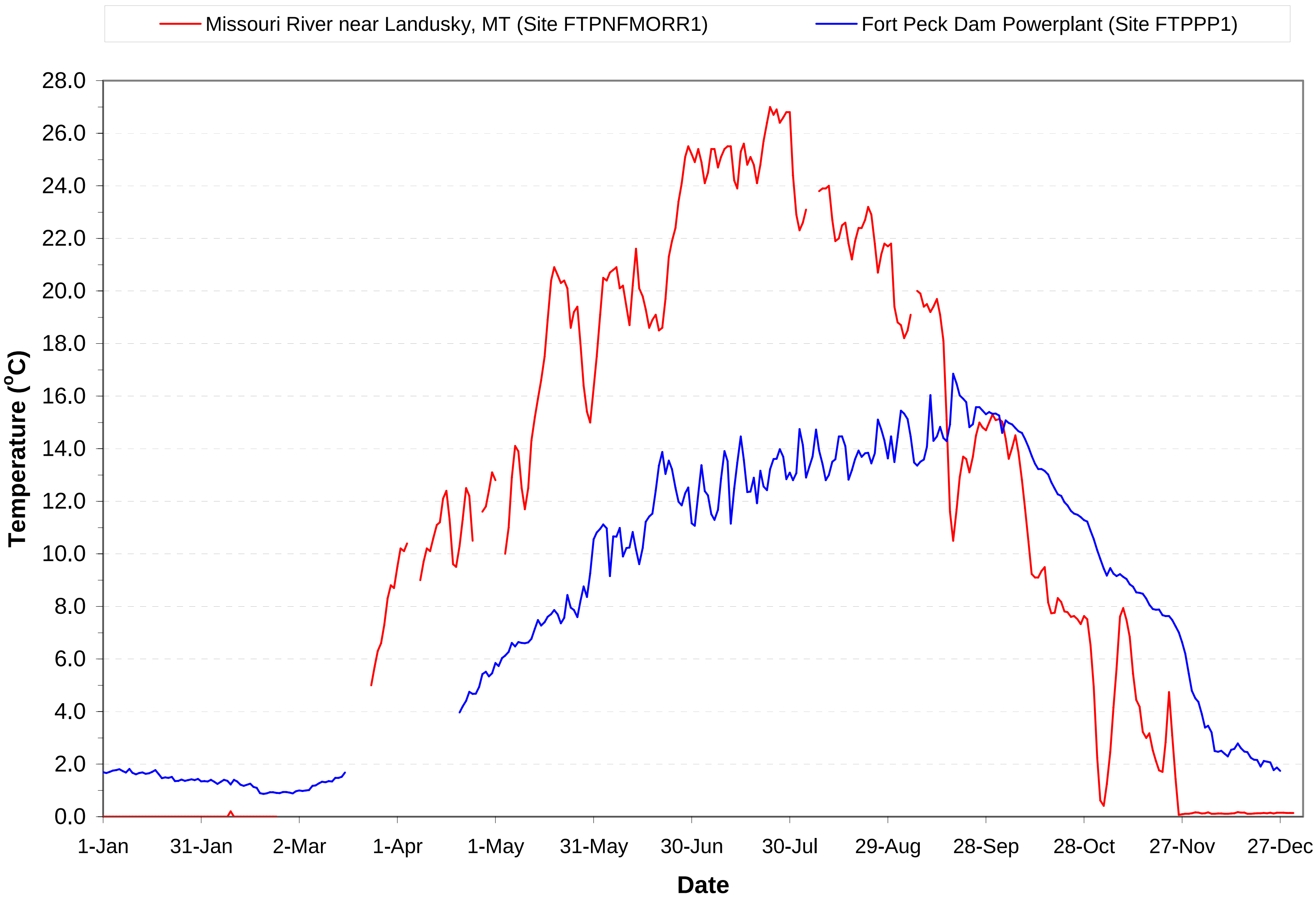


Plate 47. Mean daily water temperatures monitored at the Fort Peck Powerplant (i.e., site FTPPP1) and the Missouri River near Landusky, Montana (i.e., site FTPNFMORR1) during 2006. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

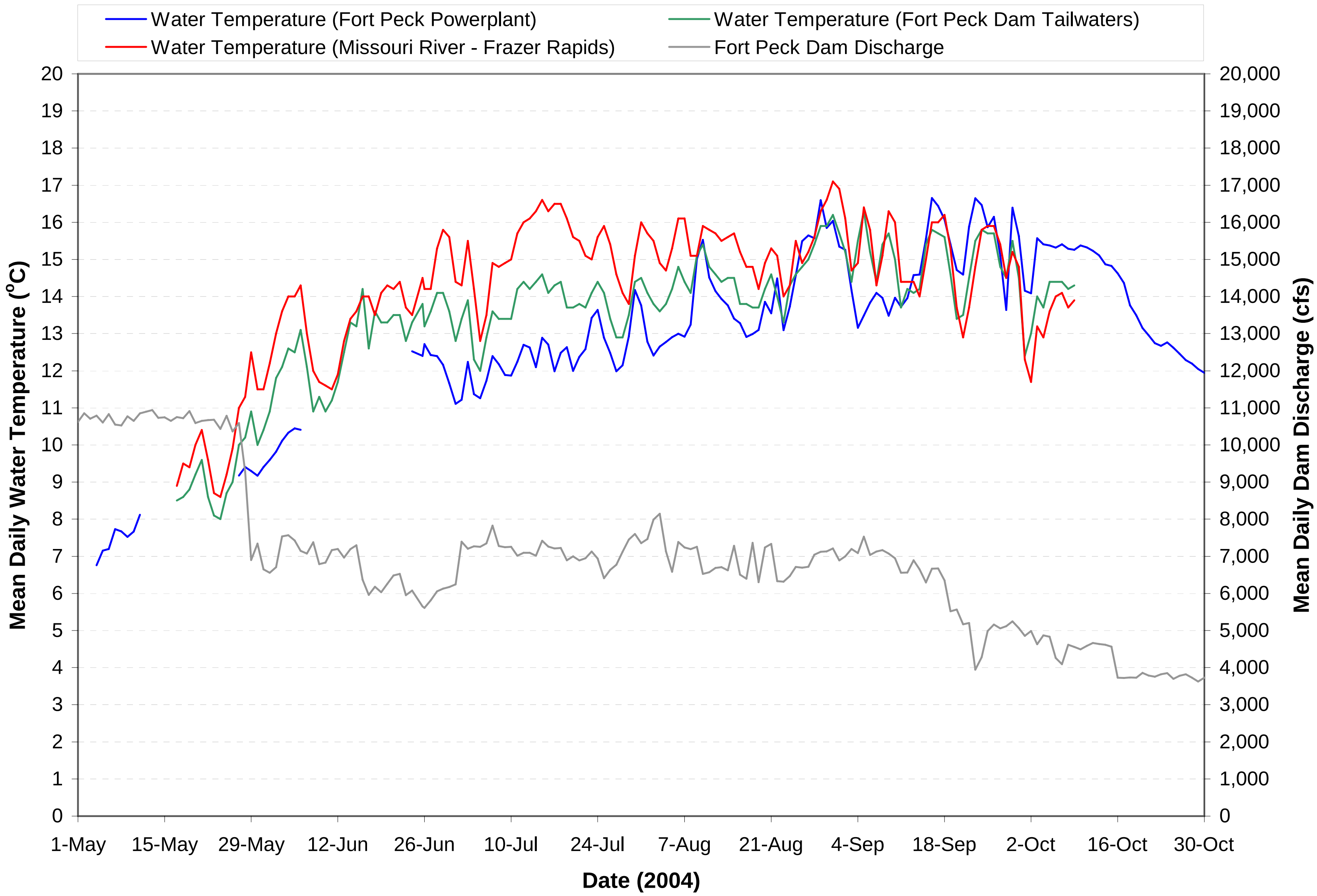


Plate 48. Mean daily water temperature monitored at the Fort Peck powerplant, Missouri River tailwaters, and Missouri River Frazer Rapids and the mean daily discharge of Fort Peck Dam from May through October during 2004**.**

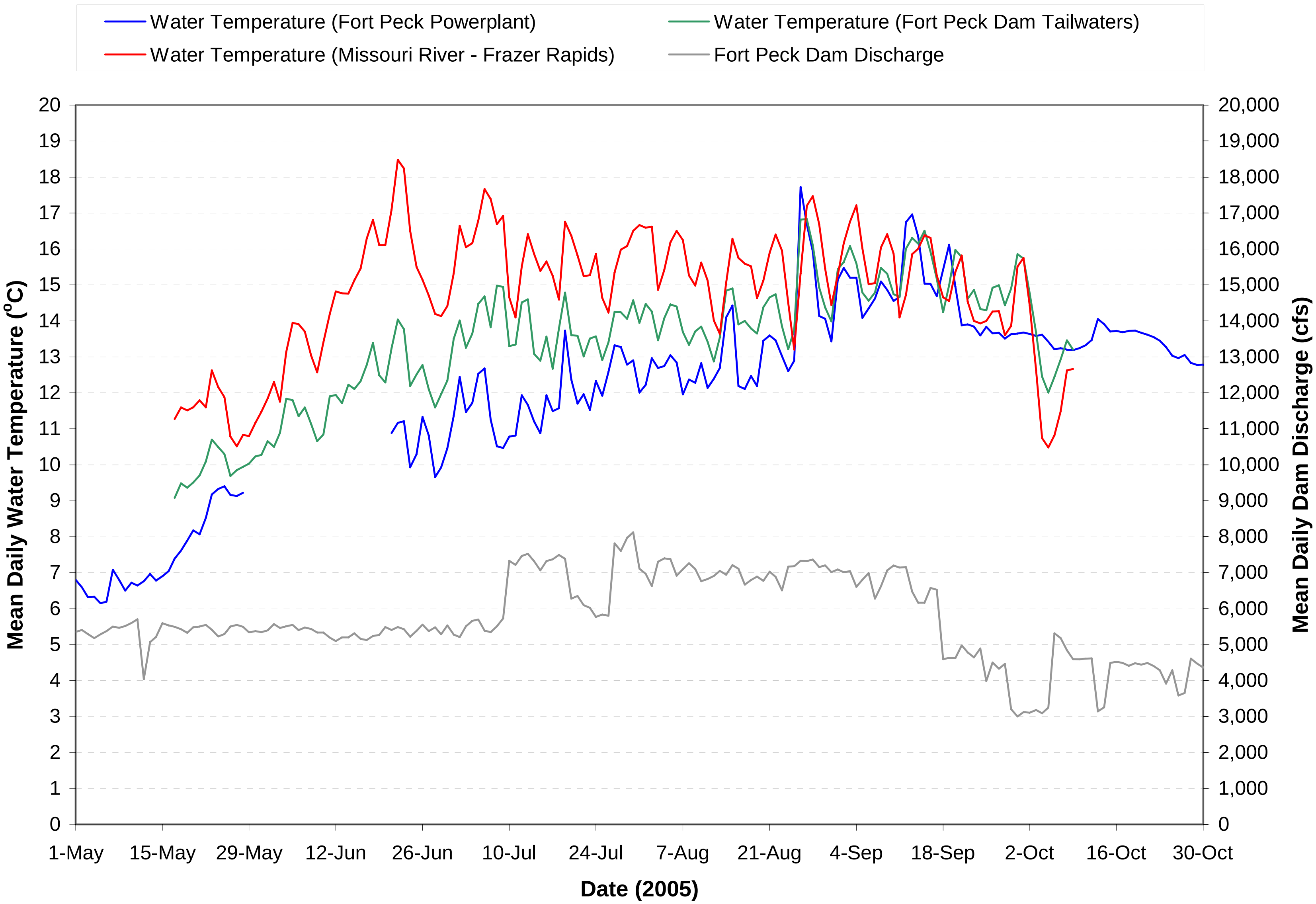


Plate 49. Mean daily water temperature monitored at the Fort Peck powerplant, Missouri River tailwaters, and Missouri River Frazer Rapids and the mean daily discharge of Fort Peck Dam from May through October during 2005.

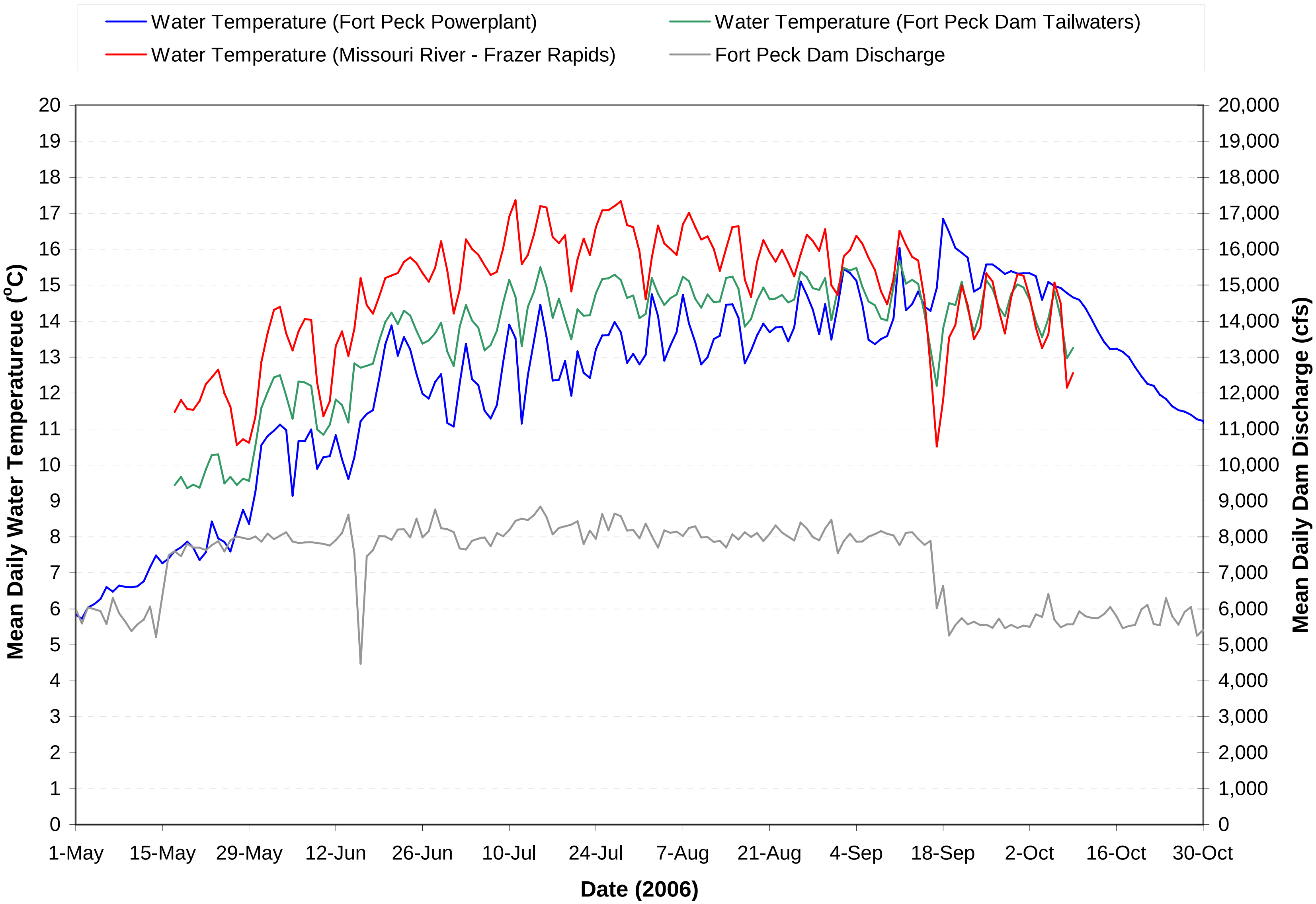


Plate 50. Mean daily water temperature monitored at the Fort Peck powerplant, Missouri River tailwaters, and Missouri River Frazer Rapids and the mean daily discharge of Fort Peck Dam from May through October during 2006.

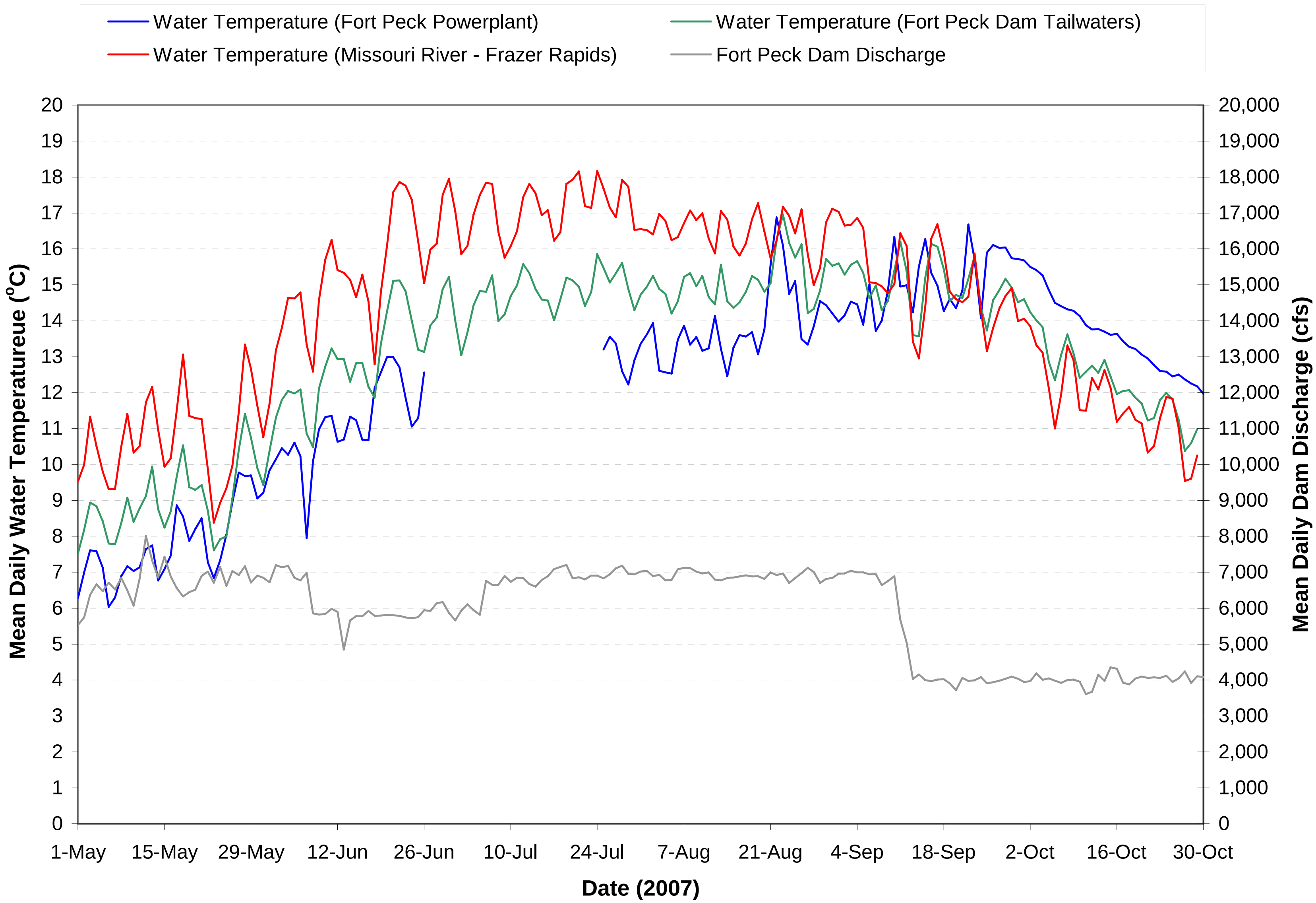


Plate 51. Mean daily water temperature monitored at the Fort Peck powerplant, Missouri River tailwaters, and Missouri River Frazer Rapids and the mean daily discharge of Fort Peck Dam from May through October during 2007.

Plate 52. Summary of monthly (May through September) water quality conditions monitored in Garrison Reservoir near Garrison Dam (Site GARLK1390A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	30	1817.1	1816.1	1807.3	1827.0	-----	-----	-----
Water Temperature (C)	0.1	1,260	14.2	14.9	6.0	23.4	29.4(1) 15.0(1)	0 623	0% 49%
Dissolved Oxygen (mg/l)	0.1	1,260	8.3	8.3	3.8	11.7	≥ 5.0	46	4%
Dissolved Oxygen (% Sat.)	0.1	1,217	84.3	89.6	37.6	114.2	-----	-----	-----
Specific Conductance (umho/cm)	1	1,217	599	608	487	652	-----	-----	-----
pH (S.U.)	0.1	1,217	8.2	8.2	7.1	8.9	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	1,215	4.7	3.0	0.1	34.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	1,217	394	387	243	538	-----	-----	-----
Secchi Depth (in.)	1	28	120	120	44	228	-----	-----	-----
Alkalinity, Total (mg/l)	7	53	164	167	140	181	-----	-----	-----
Ammonia, Total (mg/l)	0.01	55	0.16	0.04	n.d.	1.20	3.82 (2,3), 1.69 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	47	2.9	3.0	1.3	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	24	10	8	n.d.	28	-----	-----	-----
Chloride (mg/l)	1	22	8	8	7	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	859	-----	n.d.	n.d.	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	24	-----	1	n.d.	16	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	42	436	420	363	572	-----	-----	-----
Iron, Dissolved (ug/l)	40	29	-----	n.d.	n.d.	60	-----	-----	-----
Iron, Total (ug/l)	40	30	144	128	40	329	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	55	0.4	0.3	n.d.	1.6	-----	-----	-----
Manganese, Dissolved (ug/l)	1	33	-----	1	n.d.	10	-----	-----	-----
Manganese, Total (ug/l)	1	34	9	7	n.d.	26	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	55	0.08	0.07	n.d.	0 18	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	55	-----	0.02	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	55	0.05	0.03	n.d.	0.41	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	55	-----	n.d.	n.d.	0.11	-----	-----	-----
Sulfate (mg/l)	1	51	165	164	140	188	-----	-----	-----
Suspended Solids, Total (mg/l)	4	55	-----	n.d.	n.d.	12	-----	-----	-----
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	0.2	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

Plate 53. Summary of monthly (June through September) water quality conditions monitored in Garrison Reservoir near Douglas Bay (site GARLK1399DW) during the period 2003 through 2006.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	15	1819.9	1821.4	1810.1	1827.0	-----	-----	-----
Water Temperature (C)	0.1	600	15.3	16.4	7.0	22.1	29.4 15.0	0 336	0% 56%
Dissolved Oxygen (mg/l)	0.1	600	7.6	7.9	3.6	9.6	≥ 5.0	49	8%
Dissolved Oxygen (% Sat.)	0.1	600	80.1	86.6	36.7	110.0	-----	-----	-----
Specific Conductance (umho/cm)	1	600	594	604	485	642	-----	-----	-----
pH (S.U.)	0.1	600	8.0	8.1	7.1	8.7	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	600	4.4	3.3	n.d..	35.6	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	600	404	398	324	514	-----	-----	-----
Secchi Depth (in)	1	13	128	120	60	180	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater habitat in Garrison Reservoir.

Plate 54. Summary of monthly (May through September) water quality conditions monitored in Garrison Reservoir near Beulah Bay (Site GARLK1412DW) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	29	1817.4	1816.2	1809.6	1827.0	-----	-----	-----
Water Temperature (C)	0.1	1,046	15.5	16.1	6.7	23.3	29.4[1] 15.0[1]	0 615	0% 59%
Dissolved Oxygen (mg/l)	0.1	1,046	7.9	8.1	2.8	11.2	≥ 5.0	86	8%
Dissolved Oxygen (% Sat.)	0.1	1,007	82.9	88.0	28.3	108.8	-----	-----	-----
Specific Conductance (umho/cm)	1	1,007	594	598	458	648	-----	-----	-----
pH (S.U.)	0.1	1,007	8.2	8.3	6.9	9.0	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	1,001	4.9	3.2	n.d.	37.2	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	1,007	396	387	265	535	-----	-----	-----
Secchi Depth (in.)	1	27	110	112	60	150	-----	-----	-----
Alkalinity, Total (mg/l)	7	51	162	163	130	181	-----	-----	-----
Ammonia, Total (mg/l)	0.01	51	-----	0.04	n.d.	1.20	3.15 [2,3], 1 33 [2,4]	0	0%
Carbon, Total Organic (mg/l)	0.05	49	3.0	3.0	1.2	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	20	13	11	n.d.	61	-----	-----	-----
Chloride (mg/l)	1	20	9	9	8	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	706	-----	n.d.	n.d.	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	21	2	1	n.d.	7	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	51	431	420	350	613	-----	-----	-----
Iron, Dissolved (ug/l)	40	25	-----	n.d.	n.d.	70	-----	-----	-----
Iron, Total (ug/l)	40	27	279	150	60	2,380	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	51	0.4	0.3	n.d.	1.4	-----	-----	-----
Manganese, Dissolved (ug/l)	1	29	-----	1	n.d.	11	-----	-----	-----
Manganese, Total (ug/l)	1	29	17	8	n.d.	60	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	51	0.09	0.08	n.d.	0 22	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	51	-----	0.02	n.d.	0.27	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	51	0.04	0.03	n.d.	0 33	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	51	-----	n.d.	n.d.	n.d.	-----	-----	-----
Sulfate (mg/l)	1	51	164	169	120	183	-----	-----	-----
Suspended Solids, Total (mg/l)	4	51	-----	n.d.	n.d.	13	-----	-----	-----
Microcystins, Total (ug/l)	0.2	13	-----	n.d.	n.d.	0.3	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

Plate 55. Summary of monthly (June through September) water quality conditions monitored in Garrison Reservoir near Indian Hills (site GARLK1428DW) during the period 2003 through 2005.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1821.7	1822.9	1813.8	1827.0	-----	-----	-----
Water Temperature (C)	0.1	375	16.2	16.8	7.3	23.0	29.4[1] 15.0[1]	0 250	0% 67%
Dissolved Oxygen (mg/l)	0.1	375	7.6	7.9	3.2	10.7	≥ 5.0	27	7%
Dissolved Oxygen (% Sat.)	0.1	375	81.9	84.9	32.0	112.4	-----	-----	-----
Specific Conductance (umho/cm)	1	375	573	570	487	640	-----	-----	-----
pH (S.U.)	0.1	375	8.1	8.2	7.1	8.5	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	375	4.7	3.7	n.d.	23.1	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	375	397	395	295	527	-----	-----	-----
Secchi Depth (in)	1	12	111	117	63	180	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1)Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater habitat in Garrison Reservoir.

Plate 56. Summary of monthly (May through September) water quality conditions monitored in Garrison Reservoir near Deepwater Bay (Site GARLK1445DW) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	28	1817.3	1816.1	1809.6	1827.0	-----	-----	-----
Water Temperature (C)	0.1	774	16.7	16.7	8.1	24.8	29.4(1) 15.0(1)	0 524	0% 68%
Dissolved Oxygen (mg/l)	0.1	774	7.5	7.8	1.0	10.6	≥ 5.0	65	8%
Dissolved Oxygen (% Sat.)	0.1	721	80.6	87.0	10.0	112.0	-----	-----	-----
Specific Conductance (umho/cm)	1	719	551	550	471	652	-----	-----	-----
pH (S.U.)	0.1	695	8.2	8.2	7.1	9.0	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	713	10.2	6.9	0.2	58.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	720	381	380	139	528	-----	-----	-----
Secchi Depth (in.)	1	25	75	72	24	148	-----	-----	-----
Alkalinity, Total (mg/l)	7	47	148	148	120	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	46	-----	0.04	n.d.	1.30	3.83 (2,3), 1.49 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	45	3.1	3.1	2.1	4.6	-----	-----	-----
Chloride (mg/l)	1	20	8	8	6	11	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	20	14	11	n.d.	58	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	510	-----	1	n.d.	14	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	21	4	2	n.d.	16	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	47	394	382	280	582	-----	-----	-----
Iron, Dissolved (ug/l)	40	24	-----	n.d.	n.d.	553	-----	-----	-----
Iron, Total (ug/l)	40	26	351	348	70	910	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	47	0.4	0.3	n.d.	1.5	-----	-----	-----
Manganese, Dissolved (ug/l)	1	26	18	6	n.d.	82	-----	-----	-----
Manganese, Total (ug/l)	1	26	51	40	4	133	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	47	0.10	0.10	n.d.	0 30	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	46	-----	0.02	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	47	0.05	0.03	n.d.	0 32	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	47	-----	n.d.	n.d.	0.07	-----	-----	-----
Sulfate (mg/l)	1	47	151	149	119	190	-----	-----	-----
Suspended Solids, Total (mg/l)	4	47	-----	4	n.d.	19	-----	-----	-----
Microcystins, Total (ug/l)	0.2	13	-----	n.d.	n.d.	0.2	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

Plate 57. Summary of monthly (June through September) water quality conditions monitored in Garrison Reservoir near Independence Point (site GARLK1454DW) during the period 2003 through 2005.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1821.1	1822.9	1813.4	1827.0	-----	-----	-----
Water Temperature (C)	0.1	280	17.3	17.4	8.3	23.8	29.4(1) 15.0(1)	0 215	0% 77%
Dissolved Oxygen (mg/l)	0.1	280	7.2	7.4	1.9	9.8	≥ 5.0	21	8
Dissolved Oxygen (% Sat.)	0.1	280	78.5	81.9	20.6	120.6	-----	-----	-----
Specific Conductance (umho/cm)	1	280	507	492	422	631	-----	-----	-----
pH (S.U.)	0.1	280	8.0	8.1	7.0	8.6	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	280	14.3	11.2	3.7	91.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	280	394	388	325	487	-----	-----	-----
Secchi Depth (in)	1	12	50	52	19	84	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater habitat in Garrison Reservoir.

Plate 58. Summary of monthly (May through September) water quality conditions monitored in Garrison Reservoir near New Town (Site GARLK1481DW) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	27	1817.6	1816.2	1809.6	1827.0	-----	-----	-----
Water Temperature (C)	0.1	411	18.8	19.1	12.0	26.4	29.4 (1) 15.0 (1)	0 372	0% 91%
Dissolved Oxygen (mg/l)	0.1	411	7.9	8.0	4.0	10.4	≥ 5.0	7	2%
Dissolved Oxygen (% Sat.)	0.1	396	88.2	90.7	44.3	117.4	-----	-----	-----
Specific Conductance (umho/cm)	1	395	480	489	302	660	-----	-----	-----
pH (S.U.)	0.1	396	8.3	8.3	7.4	8.8	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	395	39.2	24.7	0.4	359.8	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	395	389	397	259	618	-----	-----	-----
Secchi Depth (in.)	1	27	26	24	10	66	-----	-----	-----
Alkalinity, Total (mg/l)	7	33	130	127	79	178	-----	-----	-----
Ammonia, Total (mg/l)	0.01	33	0.21	0.05	n.d.	1.20	3 15 (2,3), 1.08 (2,4)	0, 1	0%, 3%
Carbon, Total Organic (mg/l)	0.05	32	2.9	2.8	2.0	4.3	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	10	8	8	5	16	-----	-----	-----
Chloride (mg/l)	1	10	8	8	4	11	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	298	8	5	n.d.	100	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	21	5	4	n.d.	20	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	33	350	340	240	522	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	33	0.5	0.4	0.1	1.6	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	33	-----	0.04	n.d.	0.44	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	33	-----	0.02	n.d.	0.07	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	32	0.05	0.05	n.d.	0.13	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	33	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	33	126	127	73	180	-----	-----	-----
Suspended Solids, Total (mg/l)	4	33	-----	9	n.d.	60	-----	-----	-----
Microcystins, Total (ug/l)	0.2	13	-----	n.d.	n.d.	0.5	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1)Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2)Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

Plate 59. Summary of monthly (June through September) water quality conditions monitored in Garrison Reservoir near White Earth Bay (site GARLK1493DW) during the period 2003 through 2004

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	7	1823.0	1825.0	1816.5	1827.0	-----	-----	-----
Water Temperature (C)	0.1	71	20.9	22.2	15.6	25.3	29.4 (1) 15.0 (1)	0 71	0% 100
Dissolved Oxygen (mg/l)	0.1	71	7.4	7.4	5.1	8.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	71	86.8	88.5	59.3	104.7	-----	-----	-----
Specific Conductance (umho/cm)	1	71	423	406	332	533	-----	-----	-----
pH (S.U.)	0.1	71	8.1	8.1	7.8	8.5	≥7.0 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	70	60.1	45.0	23.6	154.2	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	71	380	372	161	475	-----	-----	-----
Secchi Depth (in)	1	7	13	13	8	18	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater habitat in Garrison Reservoir.

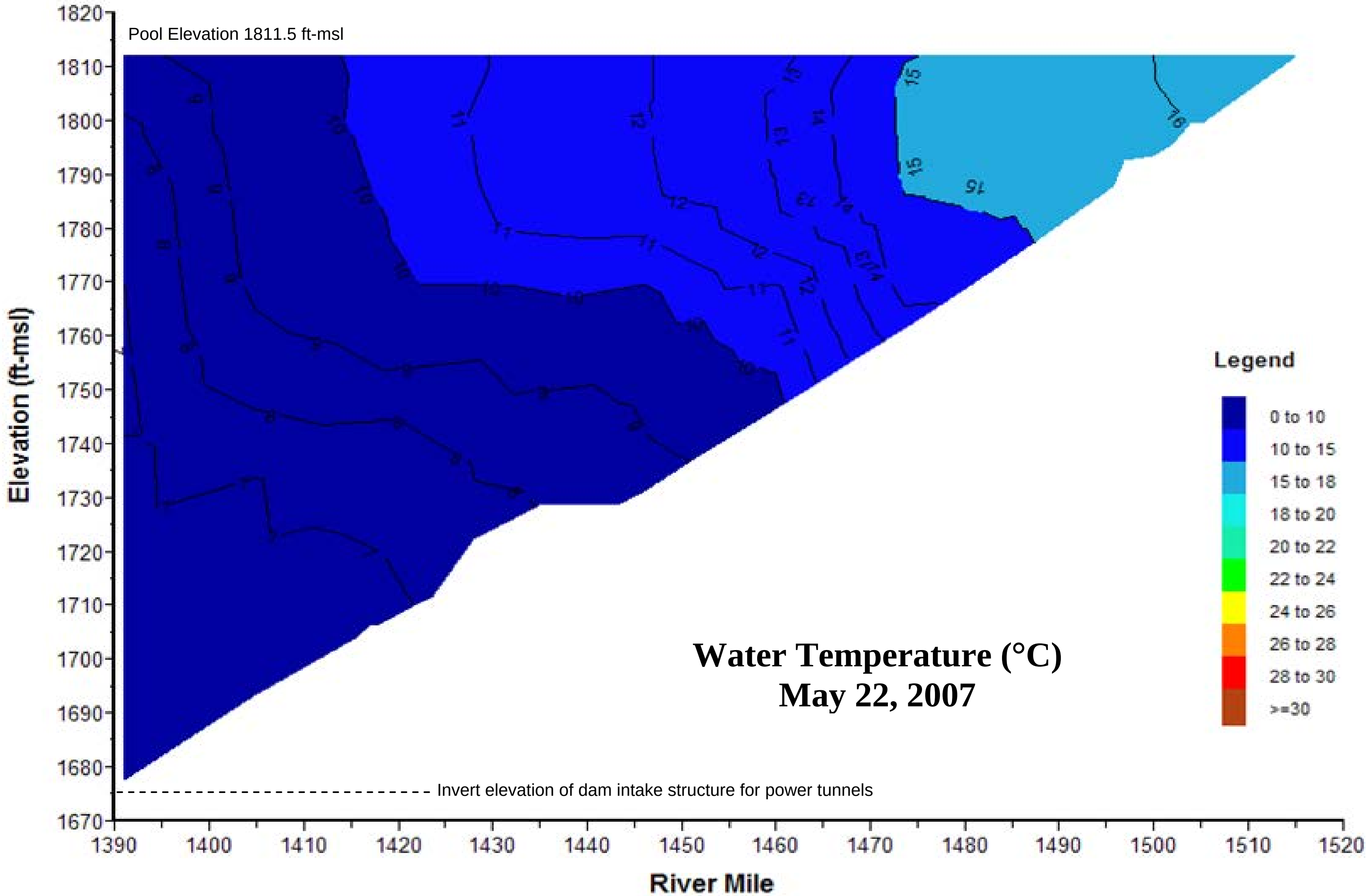


Plate 60. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on May 22, 2007.

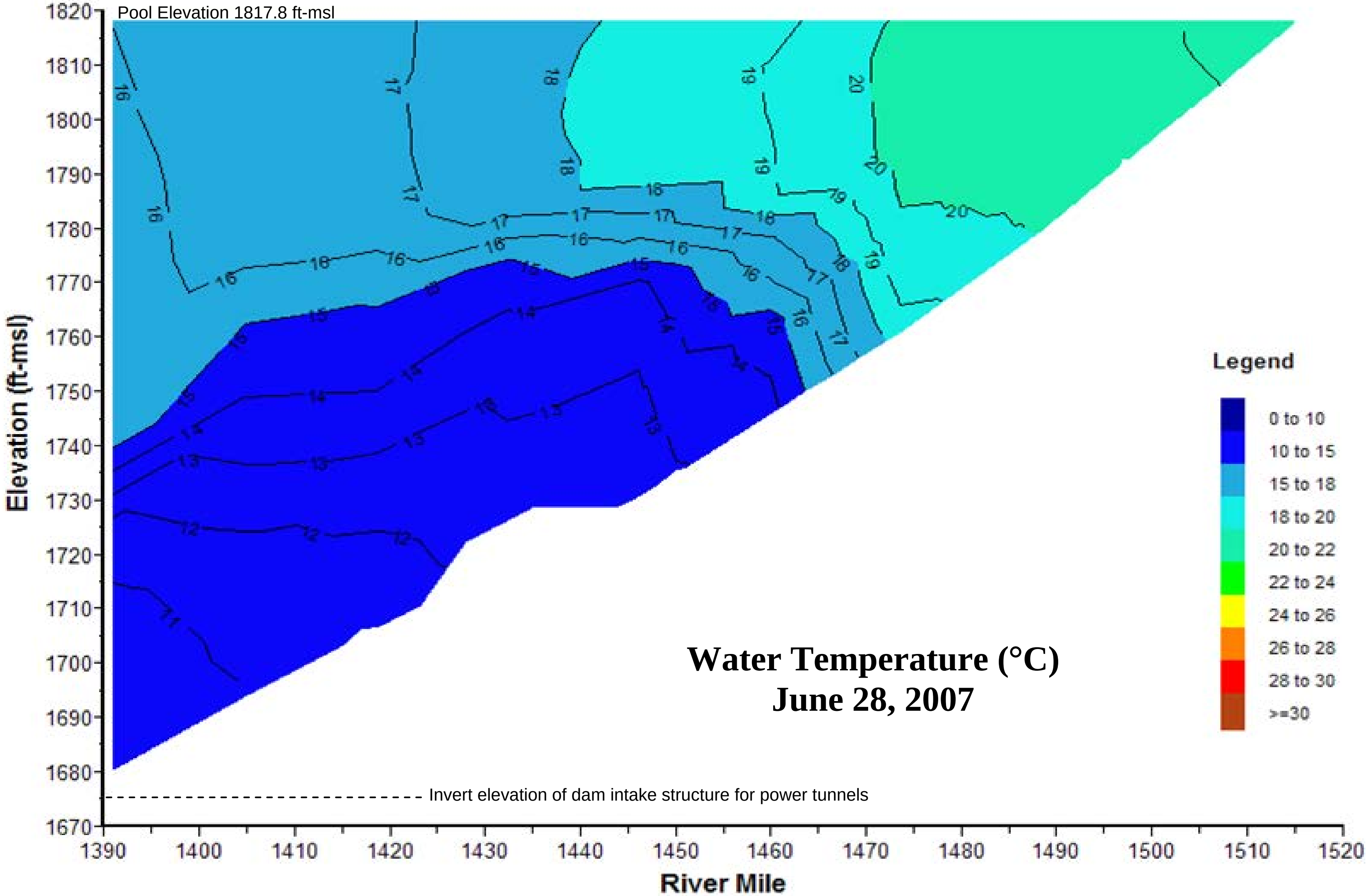


Plate 61. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on June 28, 2007.

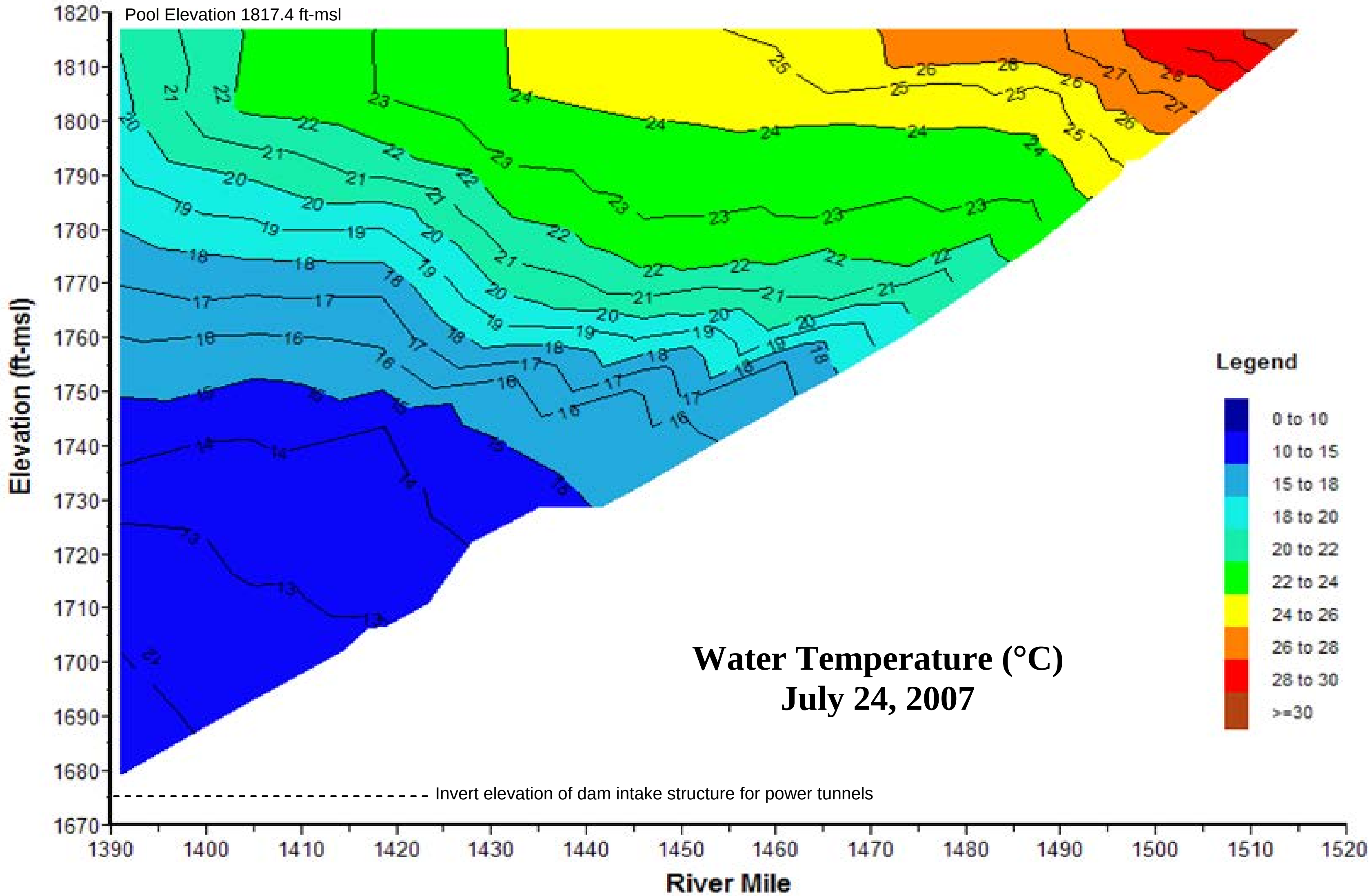


Plate 62. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on July 24, 2007.

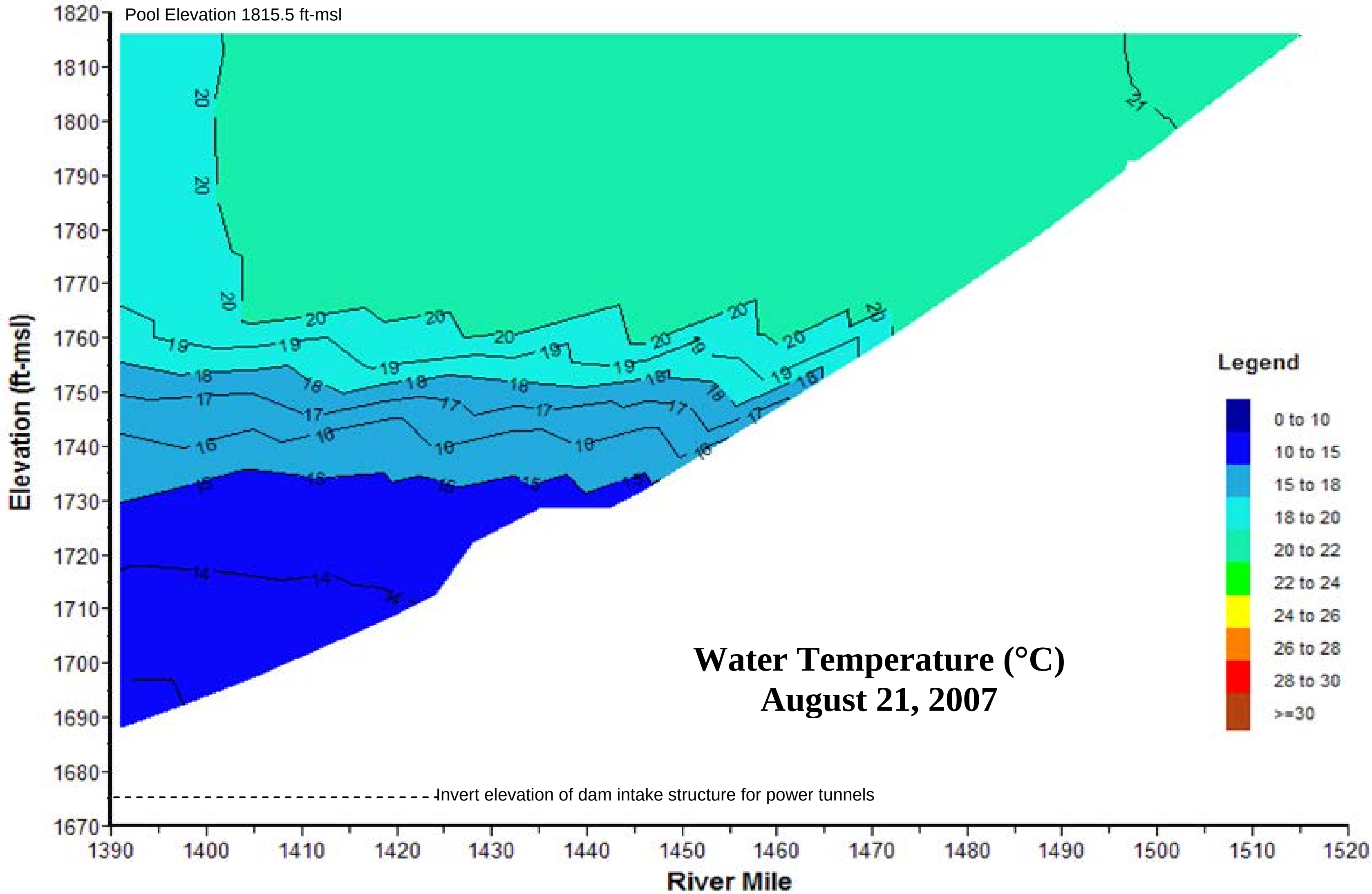


Plate 63. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on August 21, 2007.

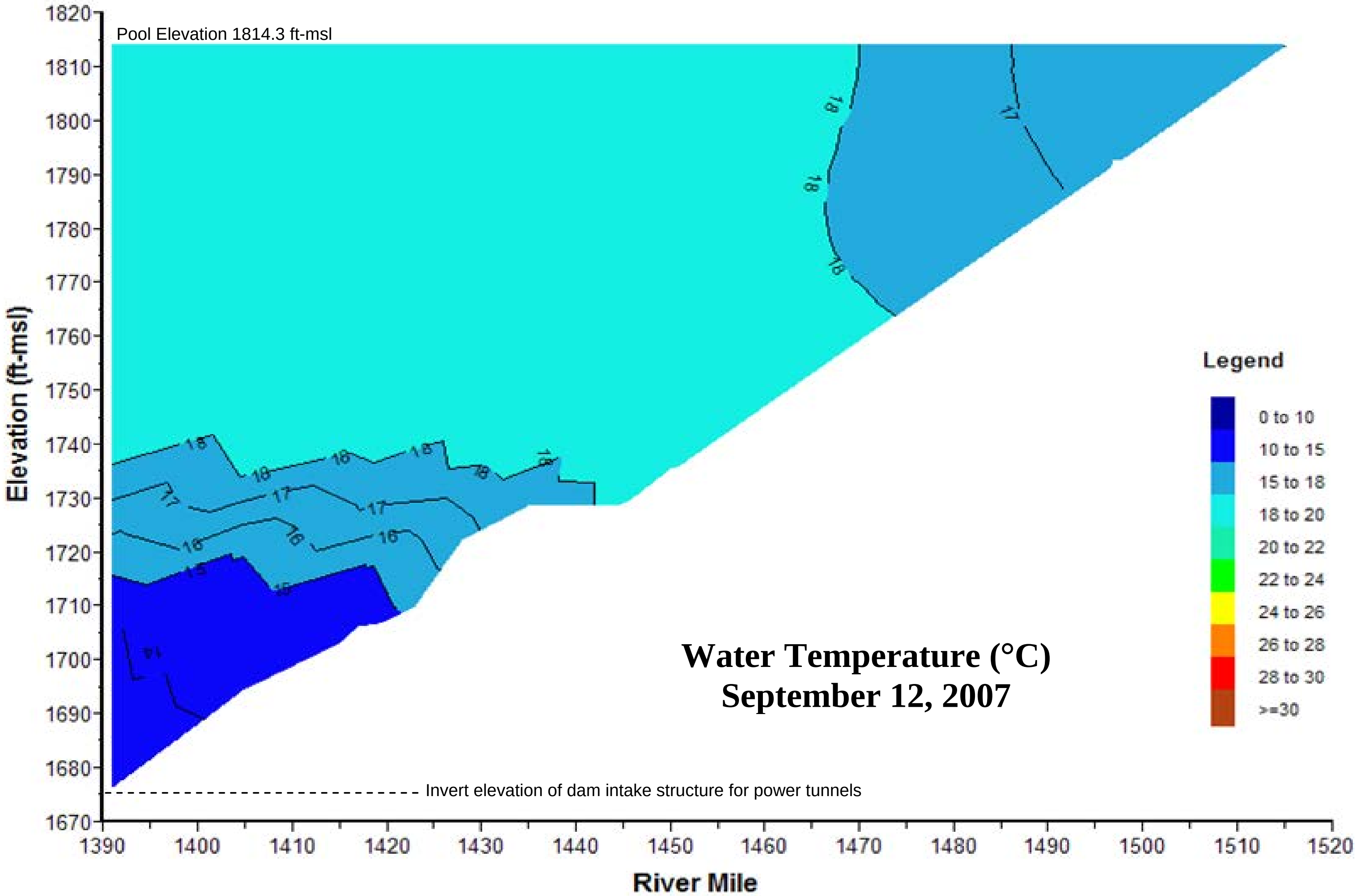


Plate 64. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on September 12, 2007.

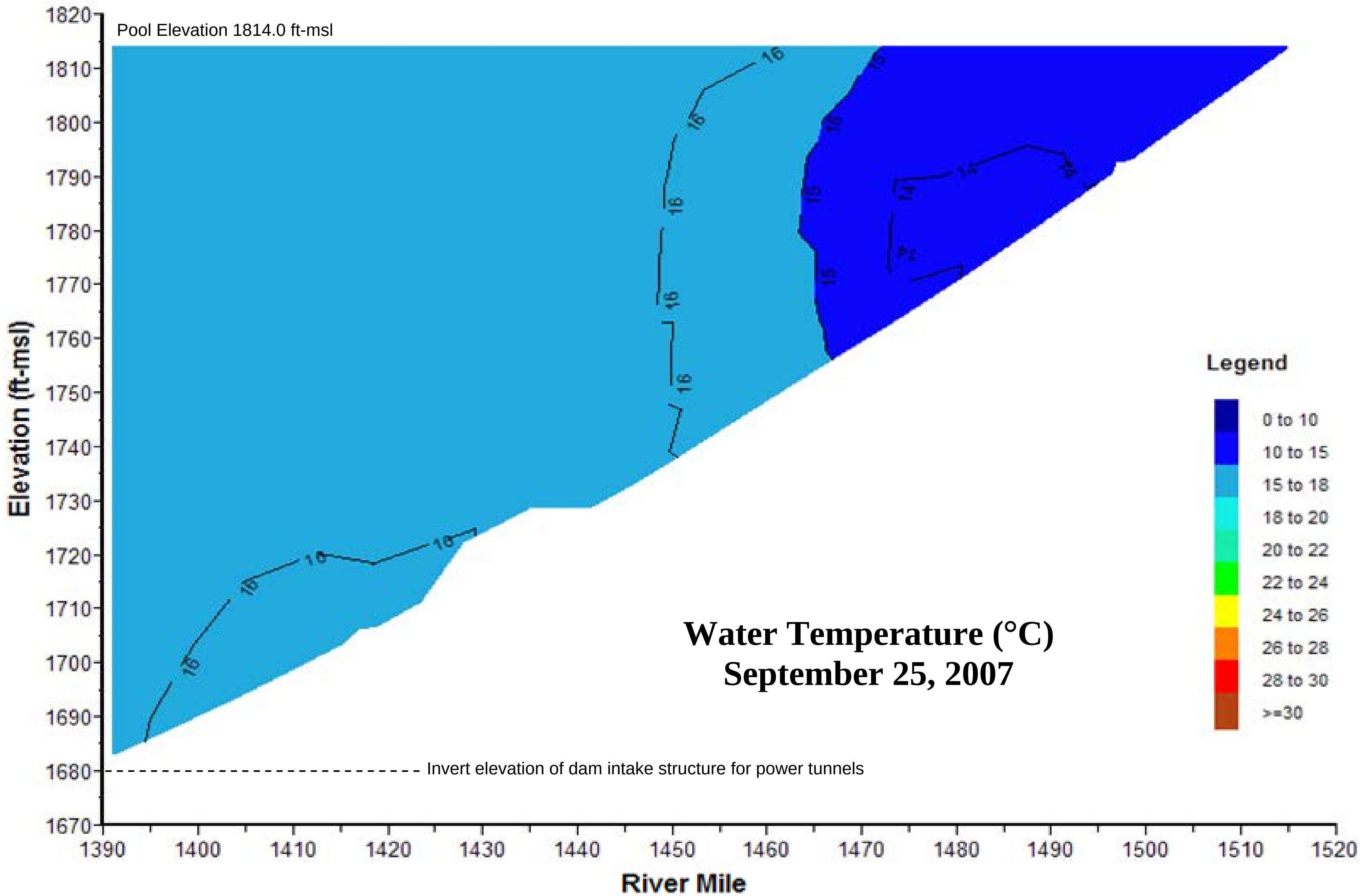


Plate 65. Longitudinal water temperature (°C) contour plot of Garrison Reservoir based on depth-profile water temperatures measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on September 25, 2007.

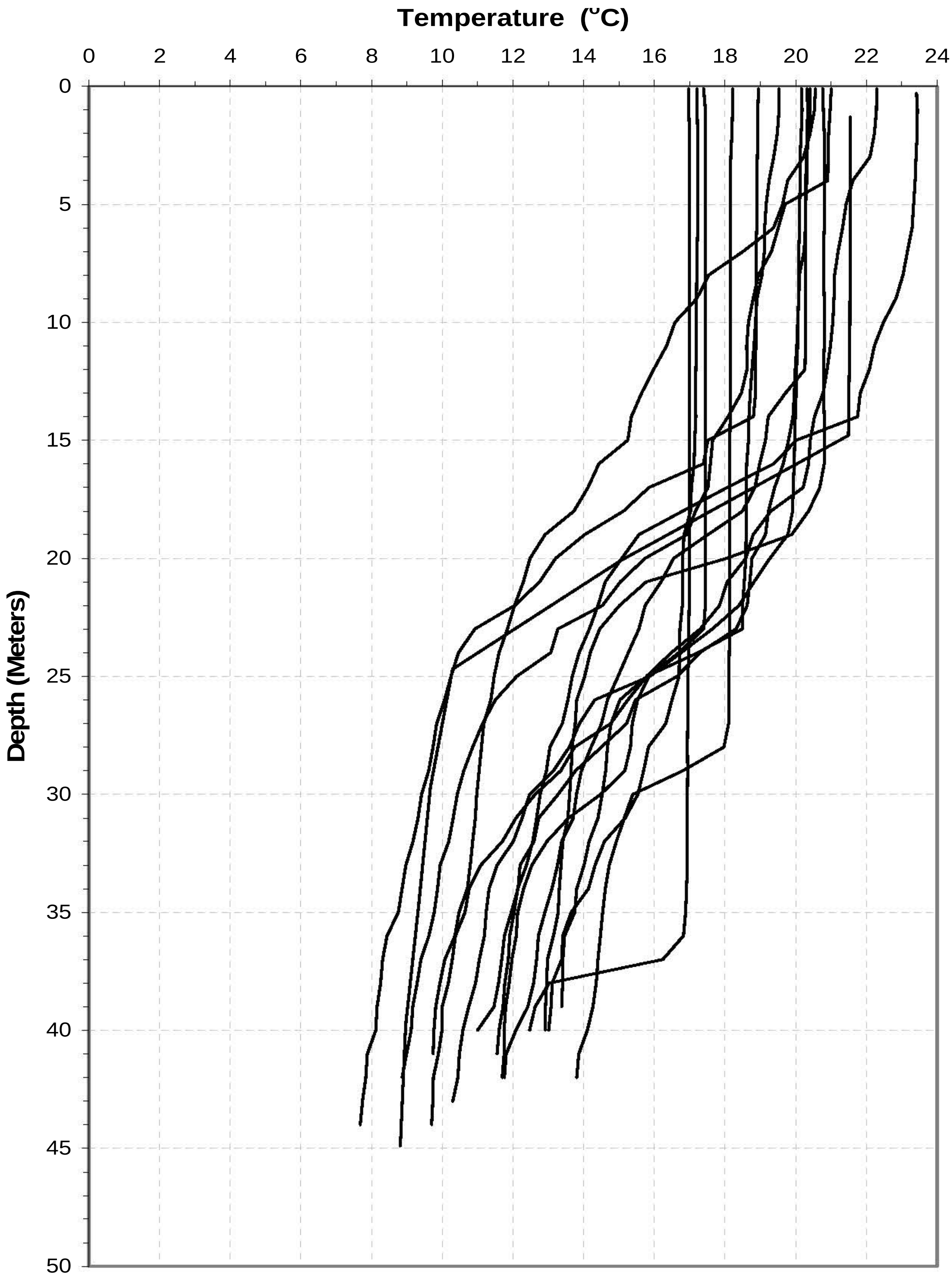


Plate 66. Temperature depth profiles for Garrison Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., GARLK1390A) during the summer months over the 5-year period of 2003 to 2007.

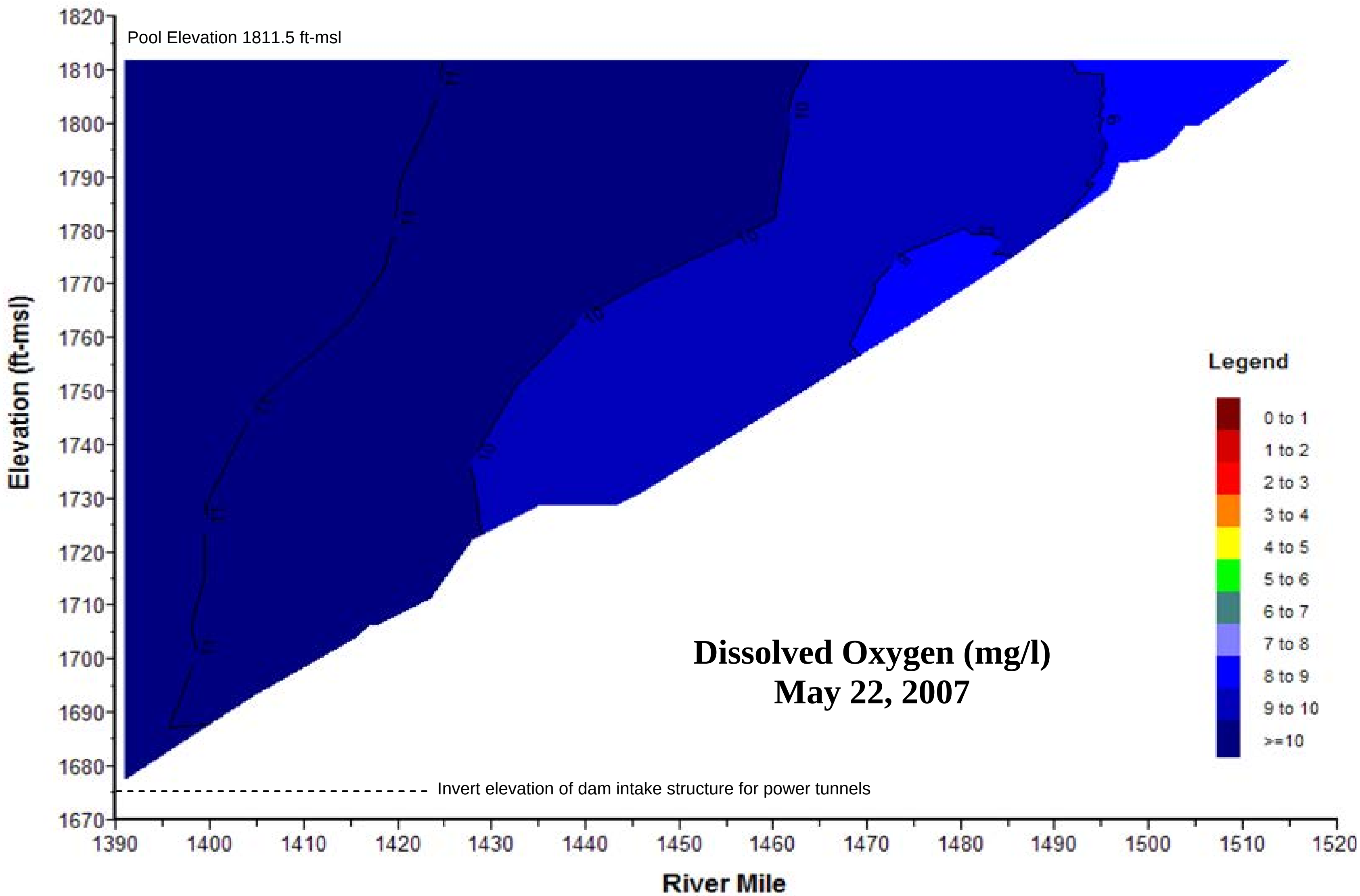


Plate 67. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on May 22, 2007.

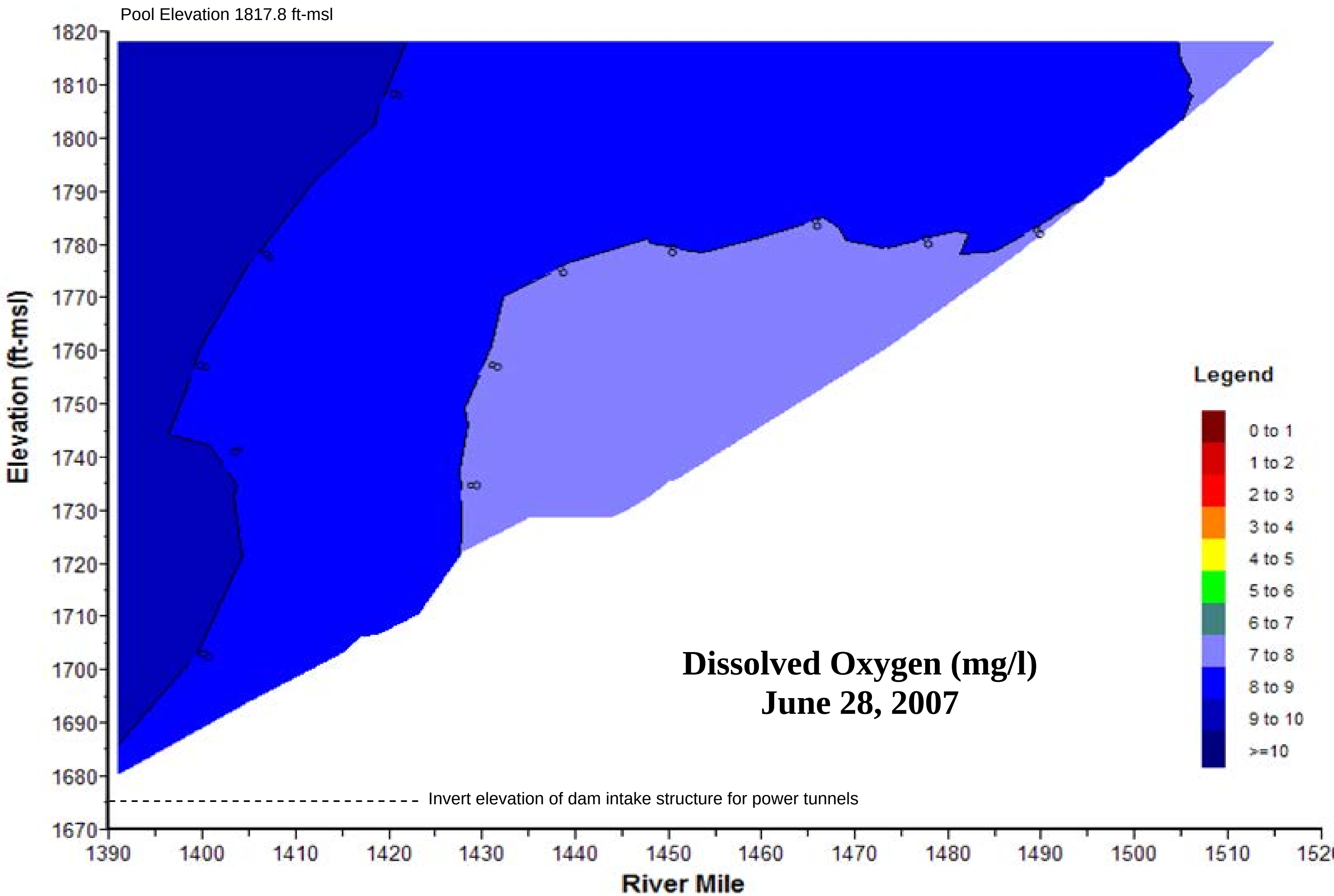


Plate 68. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations s measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on June 28, 2007.

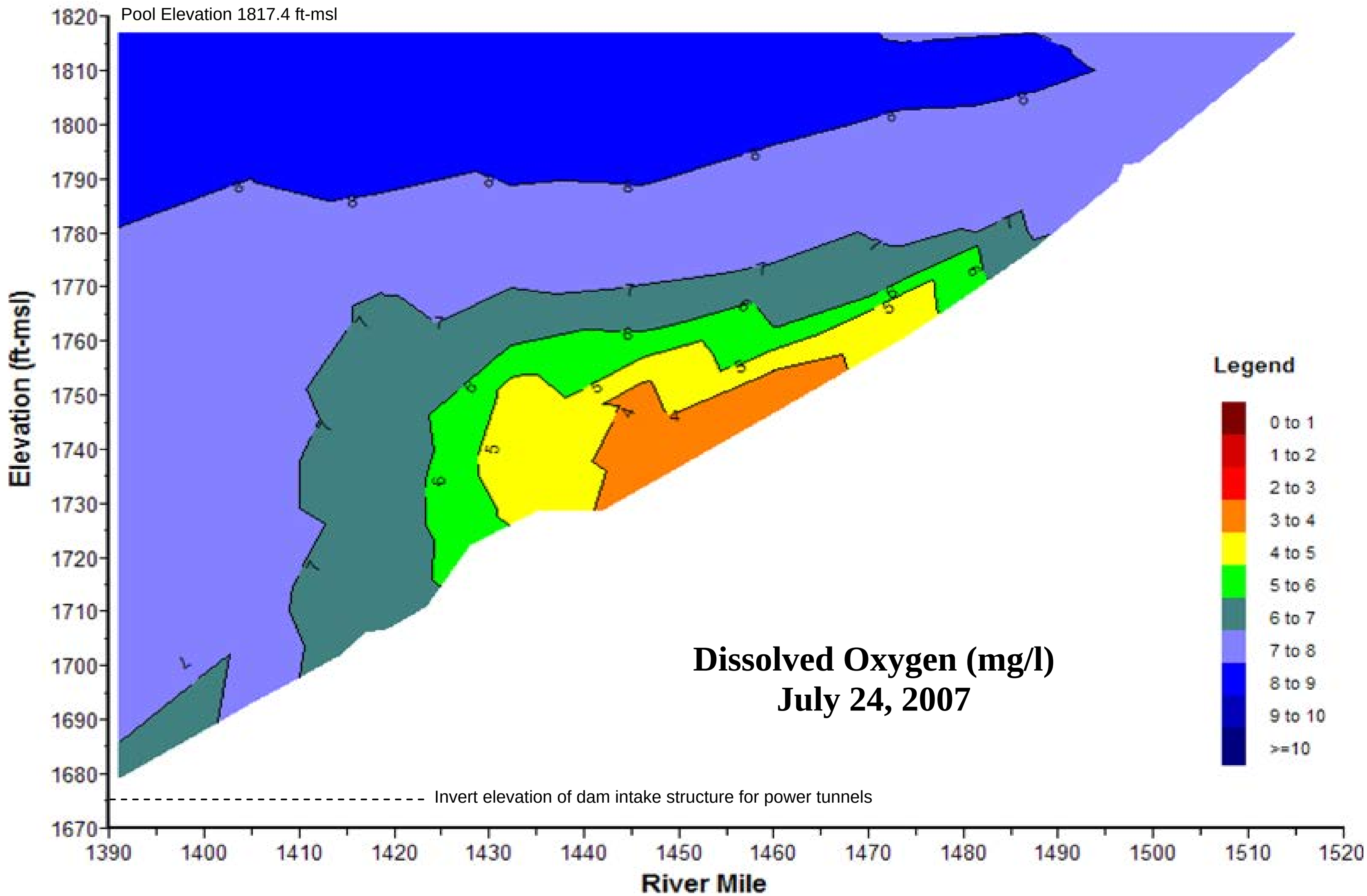


Plate 69. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on July 24, 2007.

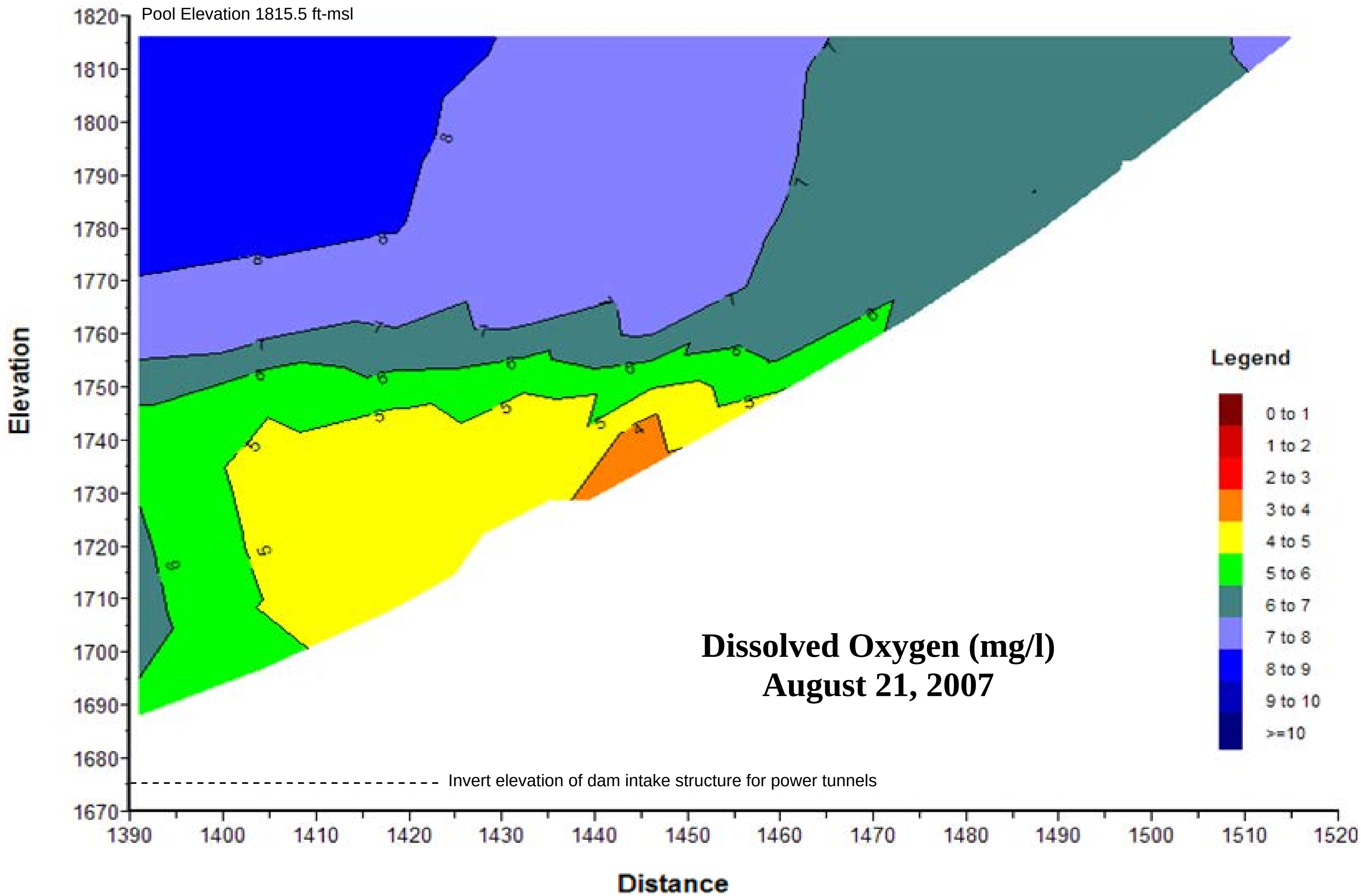


Plate 70. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on August 21, 2007.

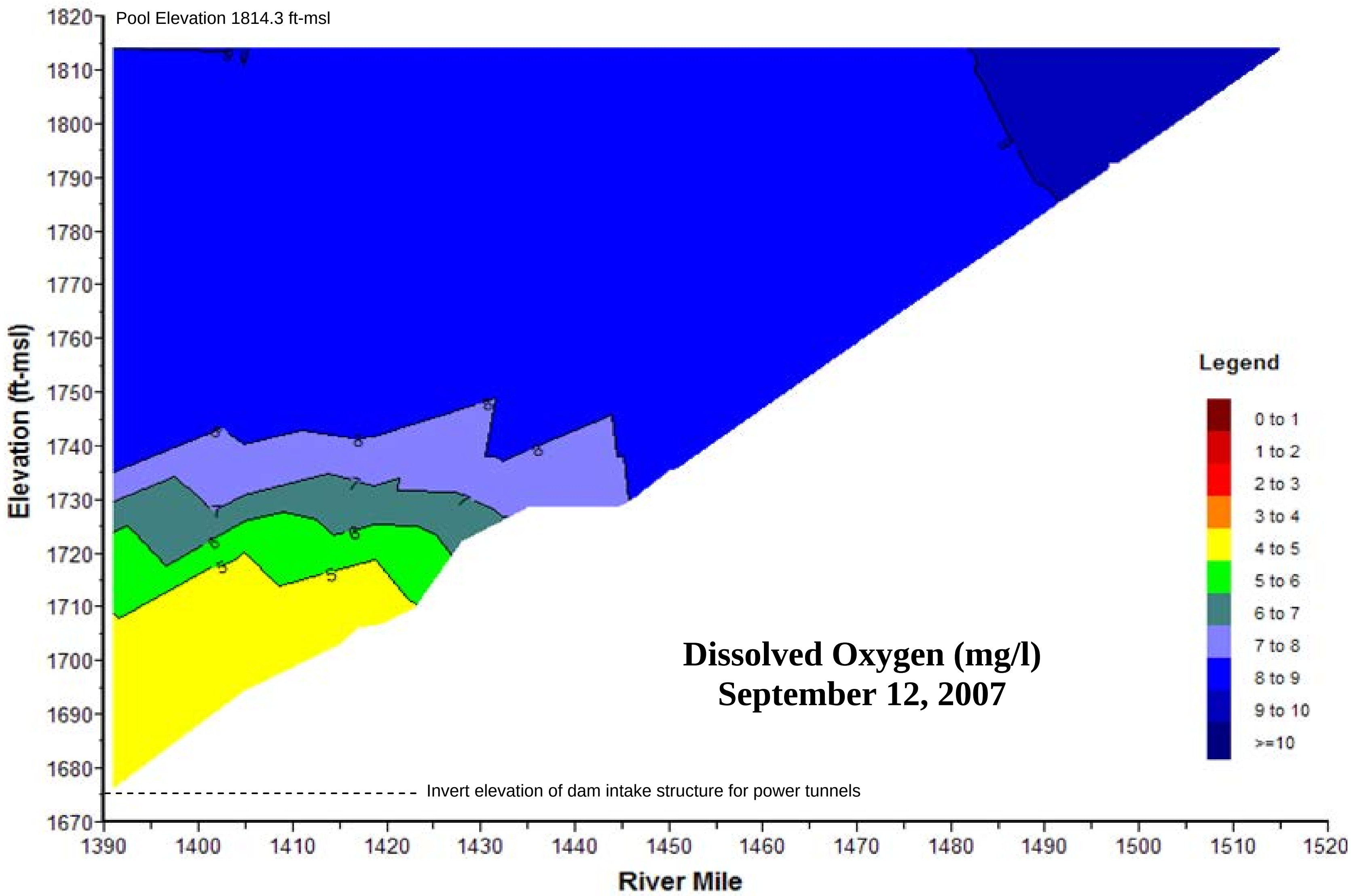


Plate 71. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on September 12, 2007.

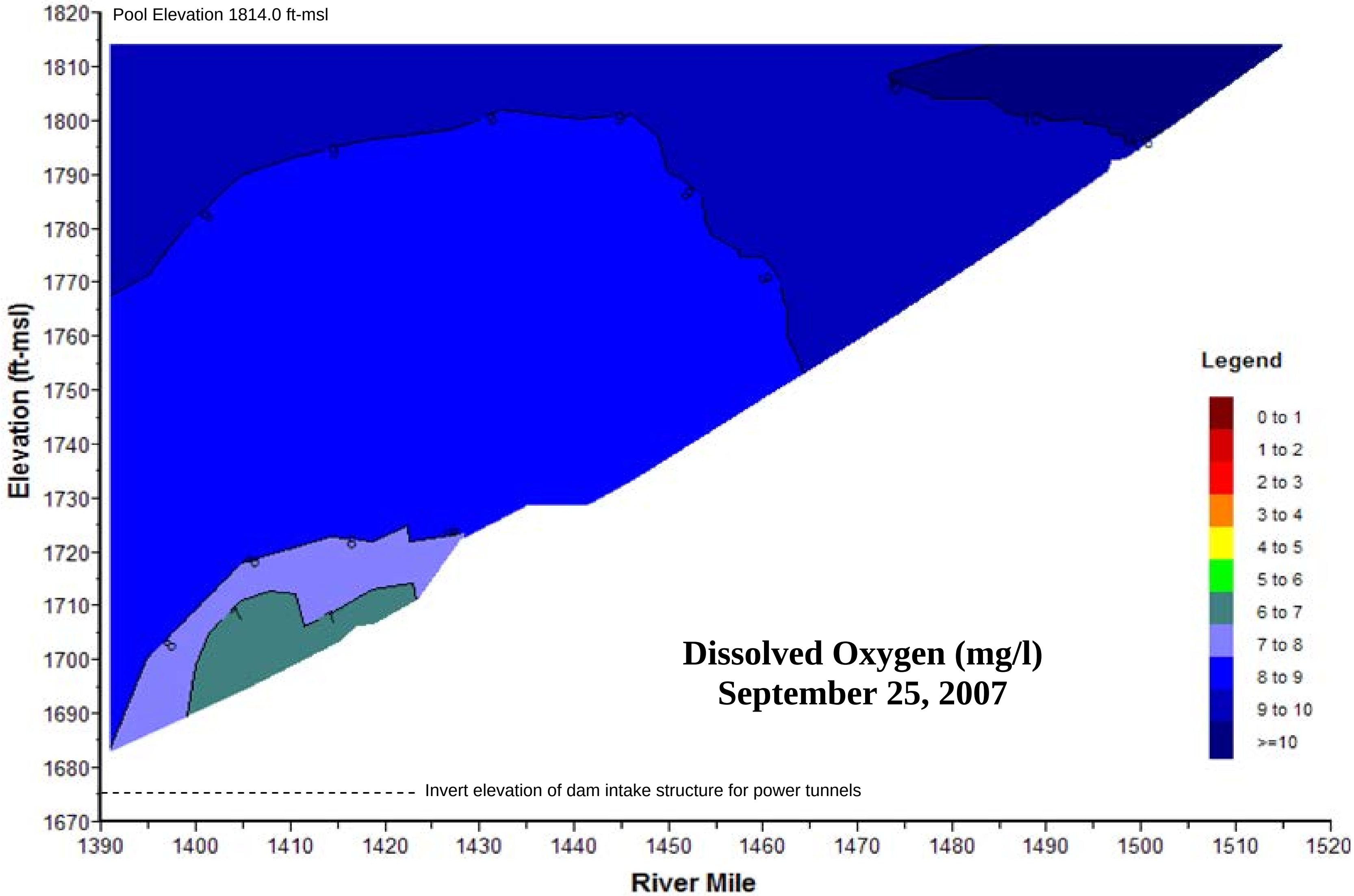


Plate 72. Longitudinal dissolved oxygen (mg/l) contour plot of Garrison Reservoir based on depth-profile dissolved oxygen concentrations measured at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on September 25, 2007.

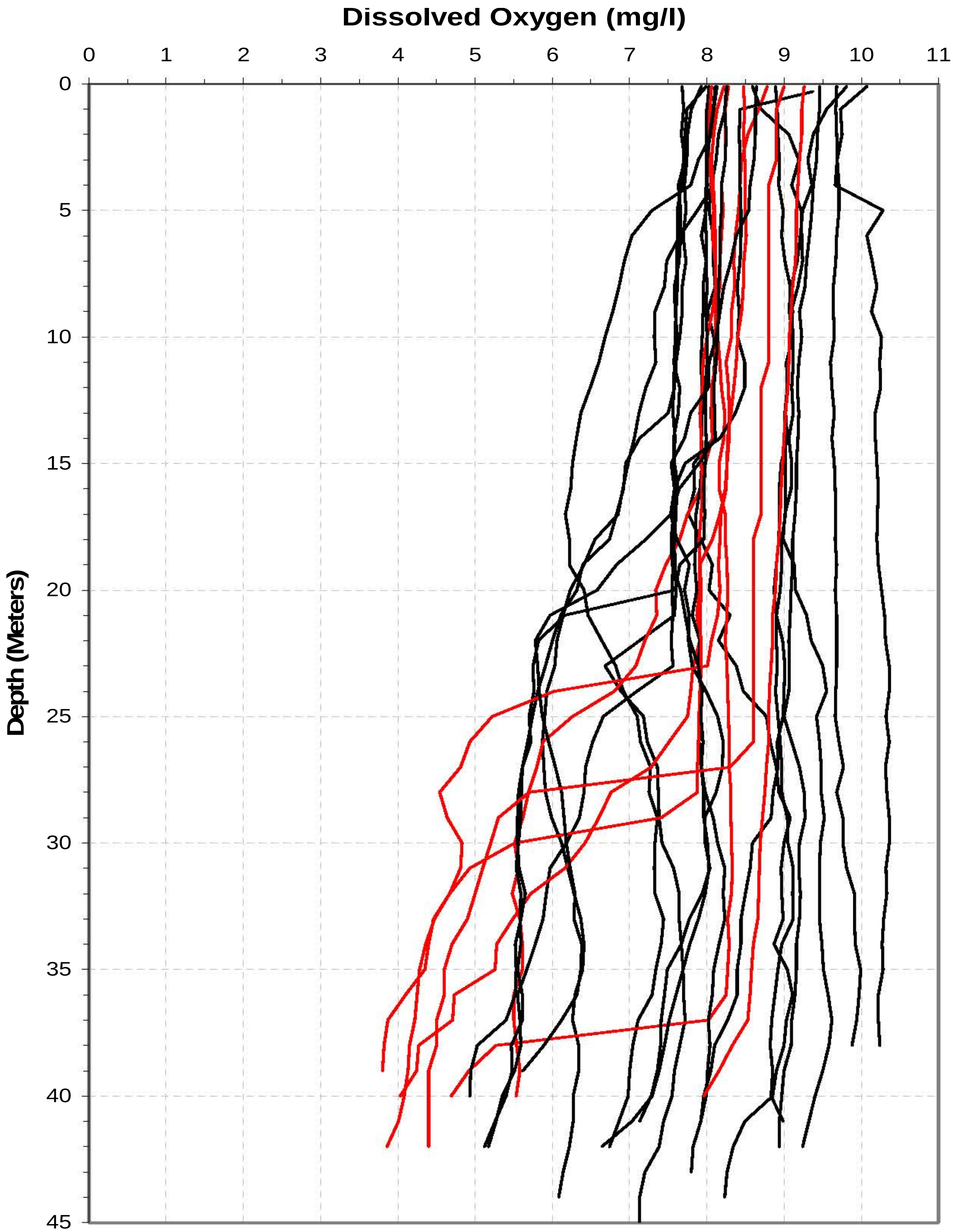


Plate 73. Dissolved oxygen depth profiles for Garrison Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., GARLK1390A) during the summer over the 5-year period of 2003 through 2007. (Note: Red profile plots were measured in the month of September.)

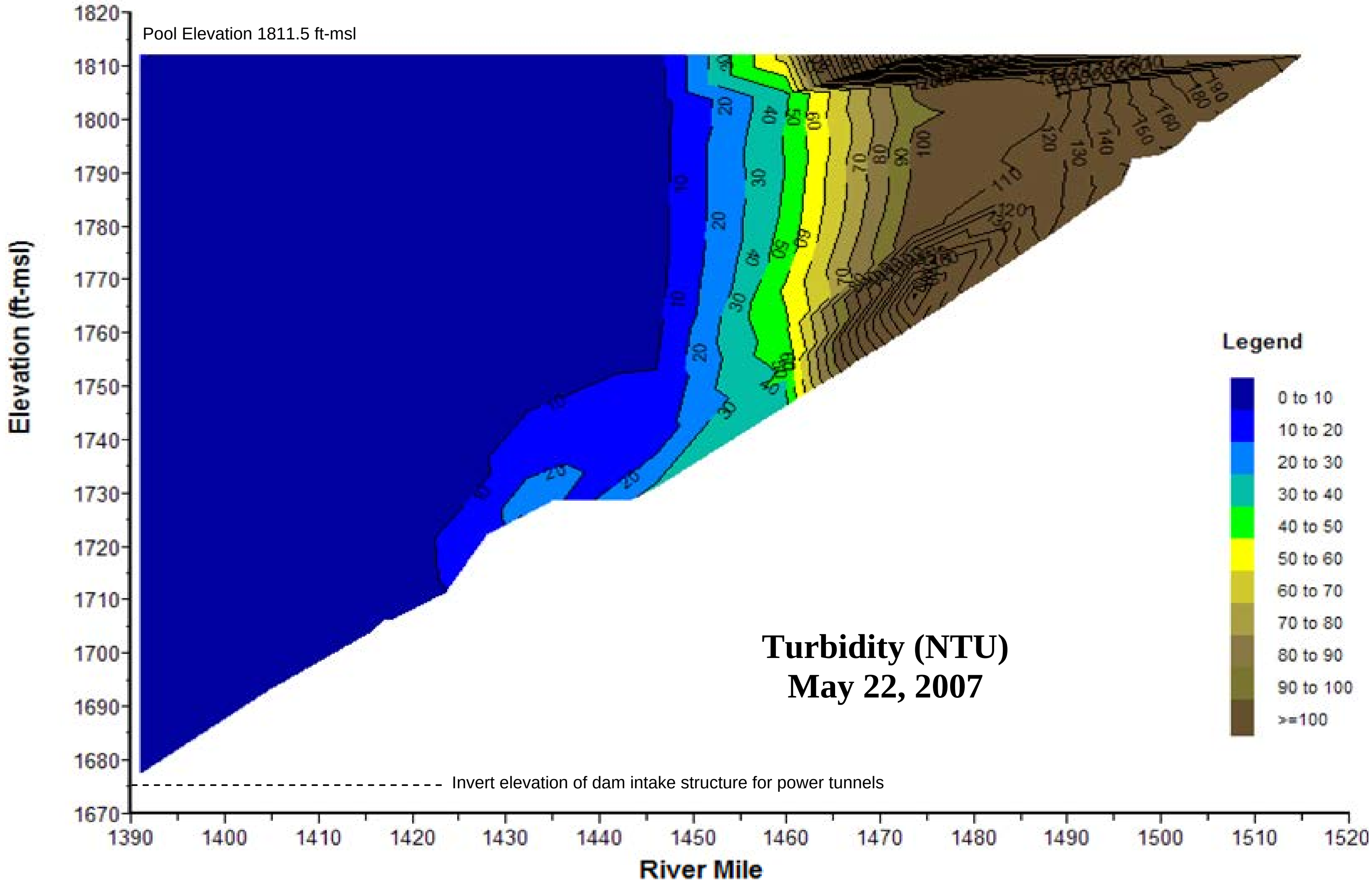


Plate 74. Longitudinal turbidity (NTU) contour plot of Garrison Reservoir based on depth-profile turbidity levels monitored at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on May 22, 2007**.**

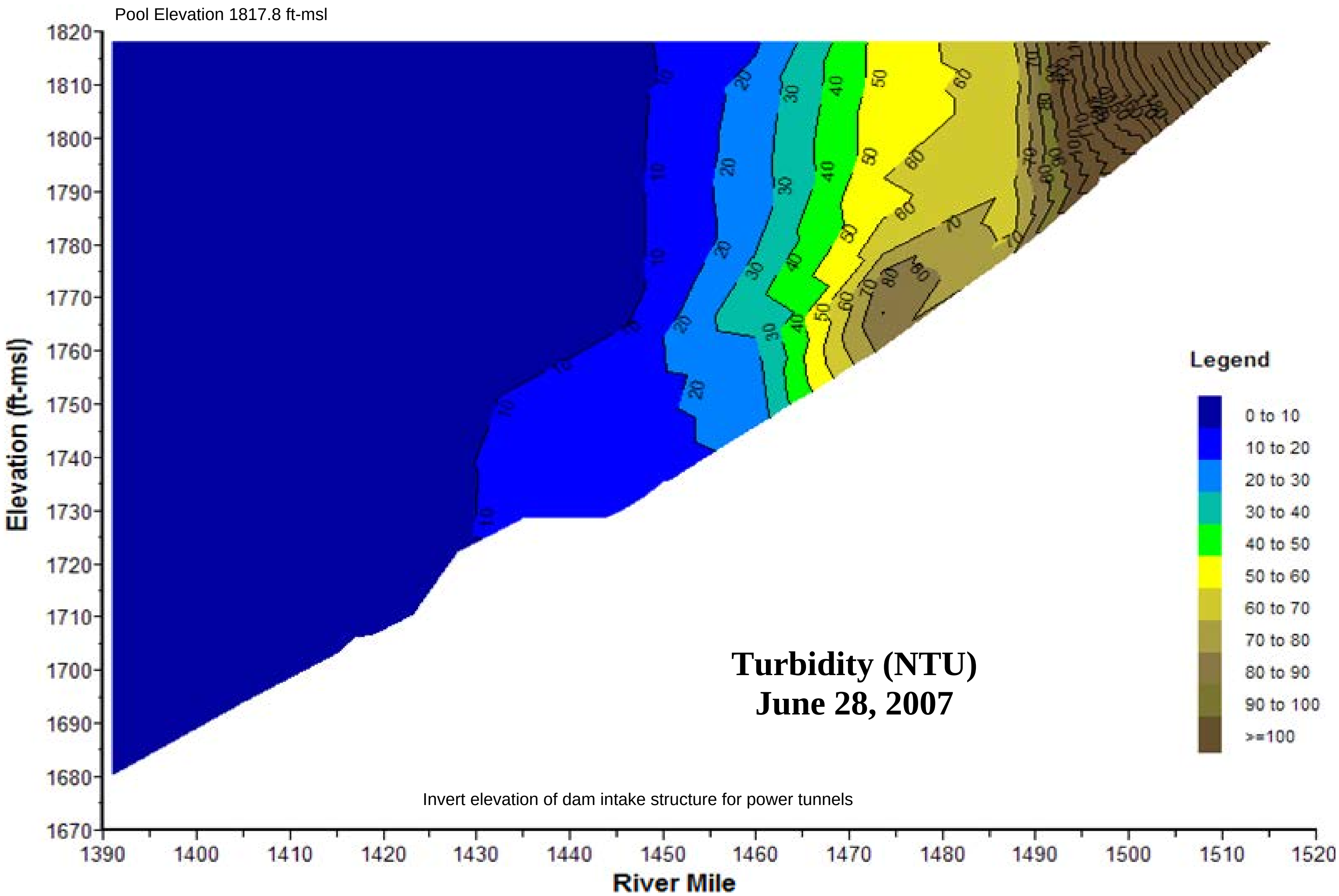


Plate 75. Longitudinal turbidity (NTU) contour plot of Garrison Reservoir based on depth-profile turbidity levels monitored at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on June 28, 2007**.**

181

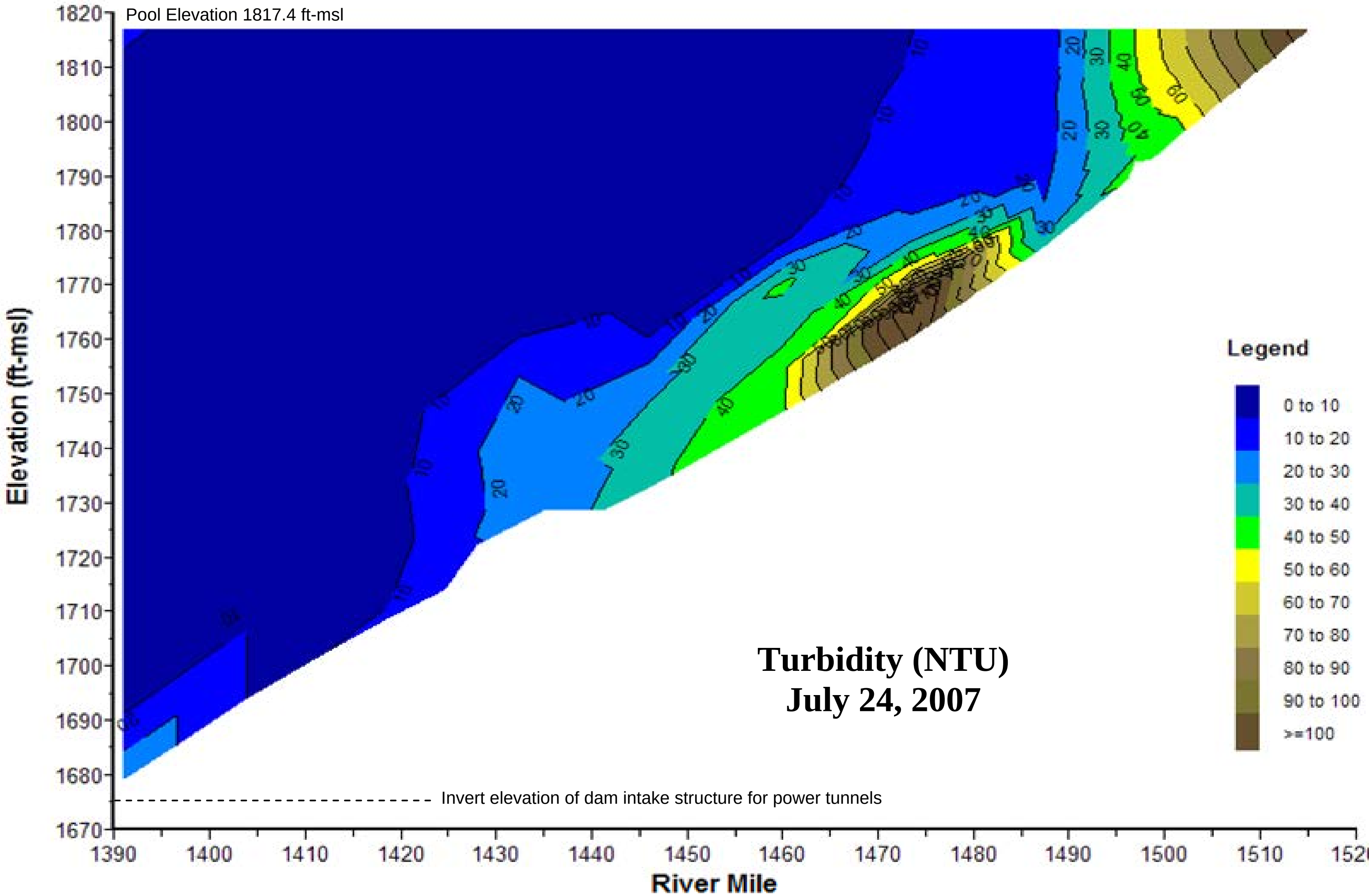


Plate 76. Longitudinal turbidity (NTU) contour plot of Garrison Reservoir based on depth-profile turbidity levels monitored at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on July 24, 2007.

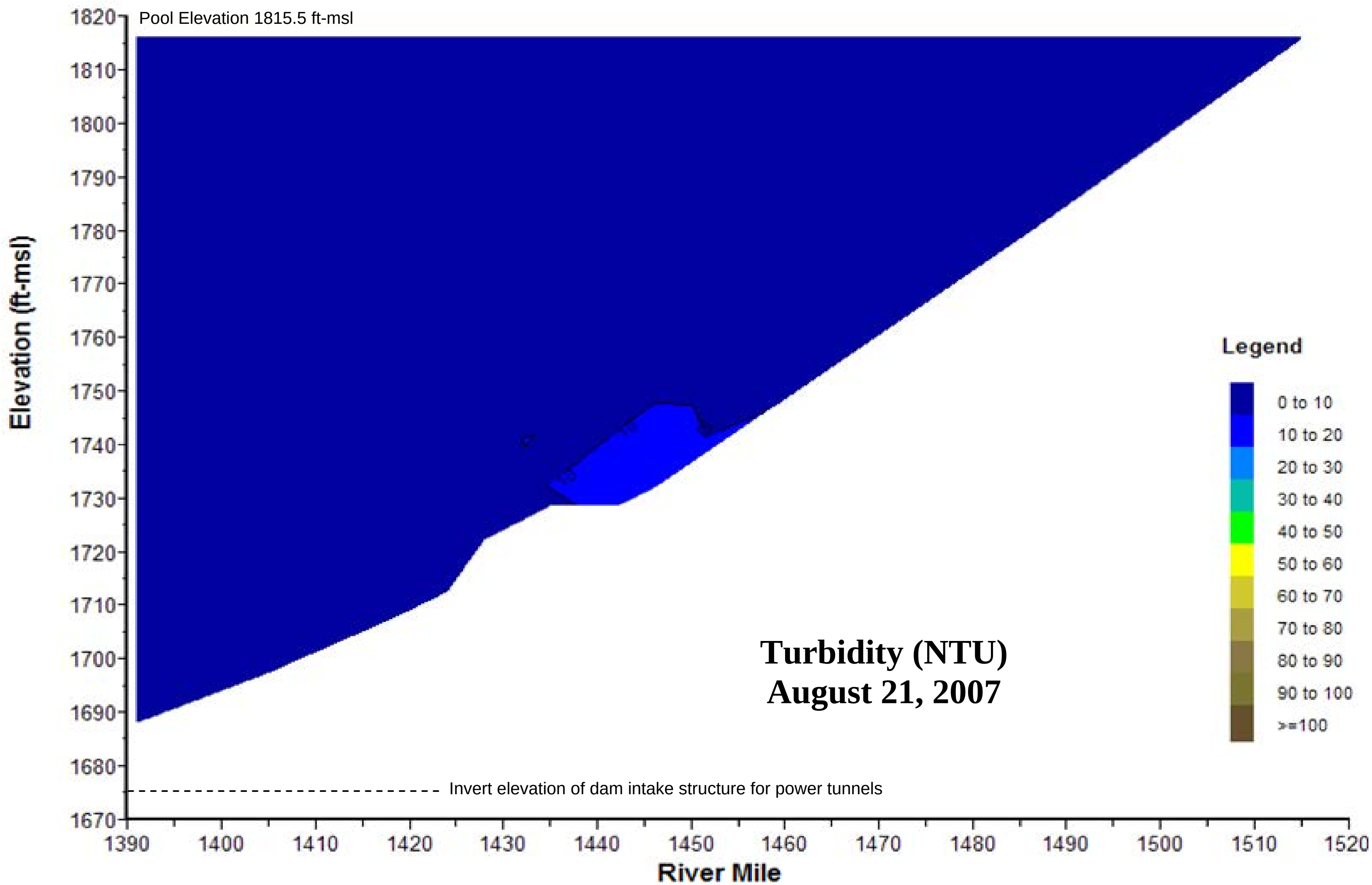


Plate 77. Longitudinal turbidity (NTU) contour plot of Garrison Reservoir based on depth-profile turbidity levels monitored at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on August 21, 2007**.**

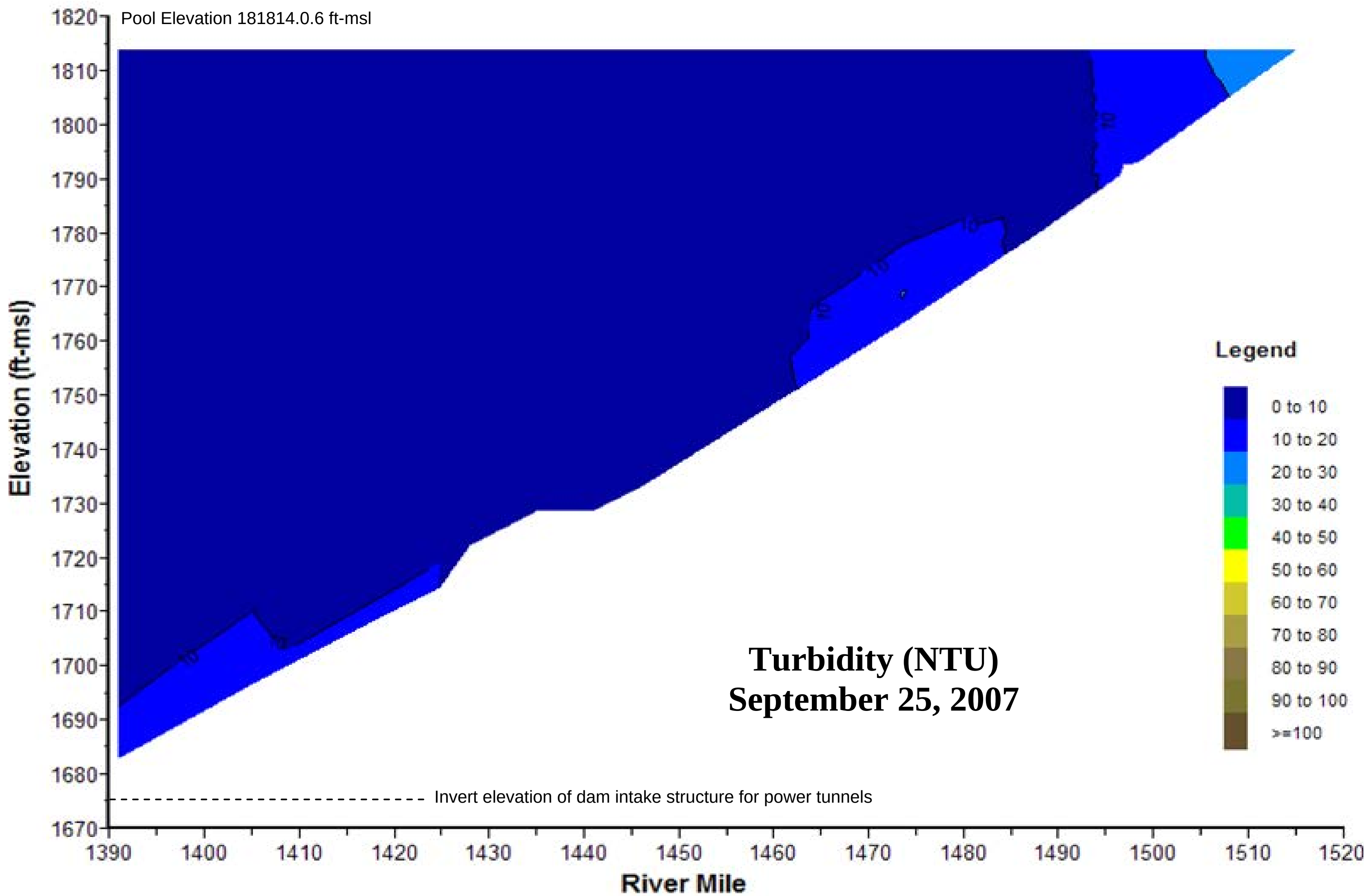


Plate 78. Longitudinal turbidity contour plot of Garrison Reservoir based on depth-profile turbidity levels monitored at sites GARLK1390A, GARLK1412DW, GARLK1445DW, GARLK1481DW, and GARNFMORRR1 on September 25, 2007.

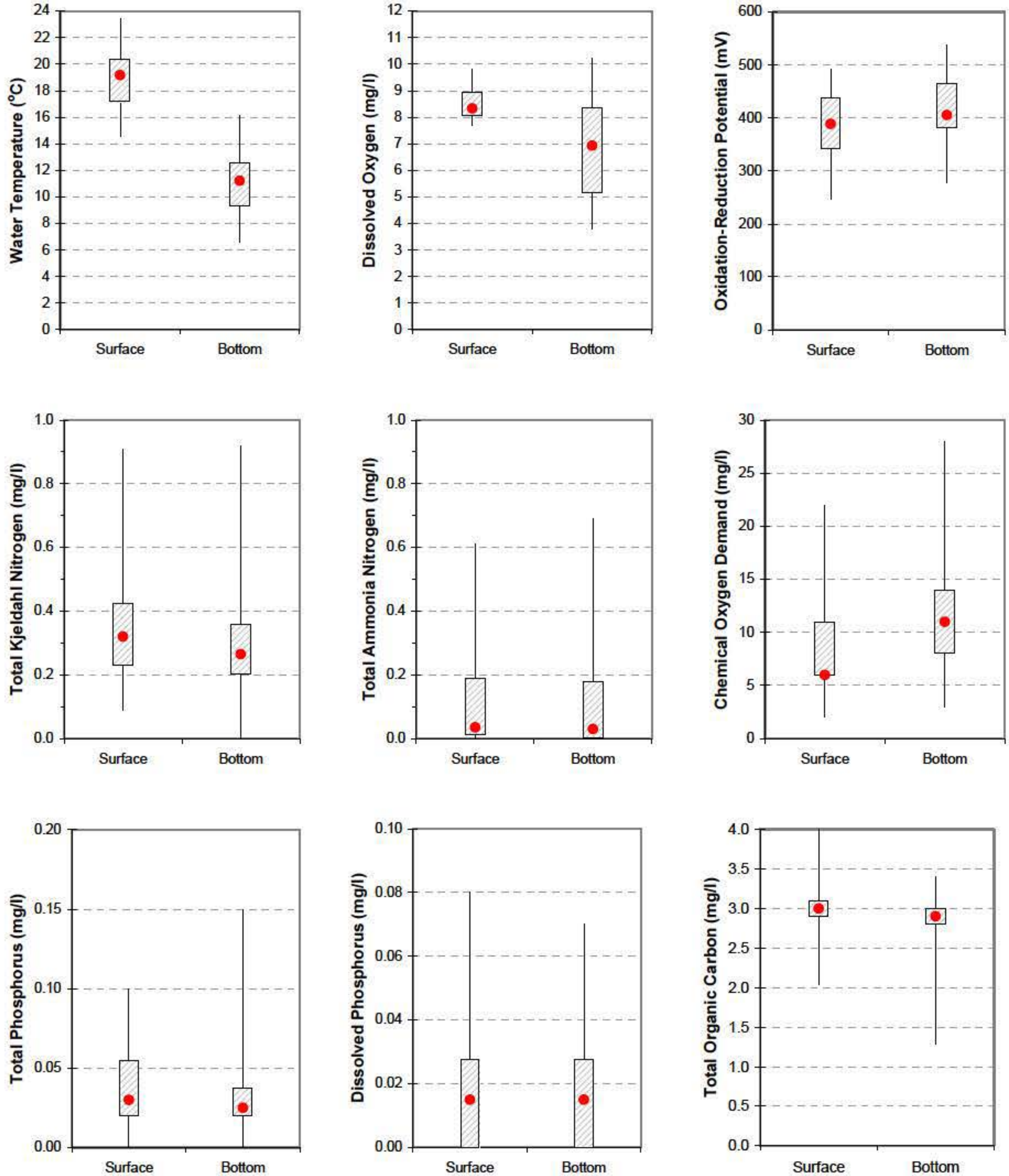


Plate 79. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measured in Garrison Reservoir at site GARLK1390A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 80. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Garrison Reservoir at site GARLK1390A during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
May 2004	18,358,561	3	0 58	0	-----	0	-----	1	0.03	1	0.02	1	0.37	0	-----	1.15
Jun 2004	1,982,256	2	0 53	0	-----	0	-----	1	0.35	2	0.12	0	-----	0	-----	1.15
Jul 2004	87,982,899	4	0.87	1	0.01	0	-----	1	0.11	3	<0.01	0	-----	0	-----	1.36
Aug 2004	102,328,294	5	0.83	2	0.01	0	-----	2	0.16	2	<0.01	0	-----	0	-----	1.03
Sep 2004	207,432,106	6	0.84	3	0.02	1	0.01	2	0.13	2	<0.01	1	<0.01	0	-----	1.62
May 2005	1,366,154,039	8	0.99	4	<0.01	1	<0.01	1	<0.01	0	-----	0	-----	0	-----	1.41
Jun 2005	6,163,686	1	0.88	0	-----	0	-----	0	-----	2	0.12	0	-----	0	-----	0.46
Jul 2005	56,944,302	7	0 57	2	0.19	0	-----	2	0.24	1	<0.01	0	-----	0	-----	1.82
Aug 2005	103,732,272	4	0.42	4	0.11	0	-----	1	0.29	2	<0.01	2	0.18	0	-----	1.93
Sep 2005	104,058,345	7	0.48	3	0.23	0	-----	2	0.29	2	<0.01	0	-----	0	-----	1.87
May 2006	4,548,278	2	0 36	5	0.45	0	-----	1	0.16	1	0.02	0	-----	0	-----	1.88
Jun 2006	207,770,143	3	0.99	2	<0.01	0	<0.01	1	0.01	1	<0.01	0	-----	0	-----	0.58
Jul 2006	95,265,098	4	0 95	3	0.01	0	-----	1	0.03	0	-----	0	-----	1	<0.01	0.41
Aug 2006	61,320,561	5	0.54	3	0.14	1	0.01	1	0.11	1	0.01	1	0.16	1	0.03	1.86
Oct 2006	149,224,845	6	0.82	2	0.09	0	-----	1	0.09	0	-----	0	-----	1	<0.01	1.23
May 2007	233,328,700	7	0.82	2	0.05	1	0.05	1	0.03	0	-----	1	0.05	0	-----	1.28
June 2007	460,925,551	7	0.85	2	0.08	2	0.03	1	0.04	0	-----	1	<0.01	0	-----	0.81
July 2007	61,884,196	9	0.54	9	0.21	0	-----	1	0.21	0	-----	1	0.04	0	-----	2.29
Aug 2007	95,896,430	5	0.40	8	0.05	1	0.17	1	0.06	2	<0.01	2	0.32	0	-----	1.84
Sep 2007	115,978,027	9	0.34	6	0.18	0	-----	1	0.07	3	0.01	2	0.42	0	-----	2.07
Mean*	**177,063,929**	**5.20**	**0.68**	**3.05**	**0.11**	**0.35**	**0.04**	**0.15**	**0.13**	**1.25**	**0.02**	**0.60**	**0.17**	**0.15**	**0.01**	**1.40**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 81. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Garrison Reservoir at site GARLK1412DW during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	1,223,563	0	-----	0	-----	0	-----	2	0.41	2	0.42	1	0.17	0	-----	1.54
Jul 2004	116,657,513	5	0.76	2	0.02	0	-----	2	0.23	3	<0.01	0	-----	0	-----	1.72
Aug 2004	88,140,166	7	0.85	0	-----	0	-----	2	0.15	2	<0.01	1	<0.01	0	-----	1.94
Sep 2004	135,965,507	6	0.52	1	0.23	0	-----	2	0.20	4	0.03	1	0.02	0	-----	2.01
Jul 2005	116,539,612	5	0.09	4	0.07	1	0.20	2	0.31	2	<0.01	1	0.32	0	-----	1.89
Aug 2005	252,450,665	4	0.82	2	0.09	0	-----	2	0.07	3	0.02	0	-----	0	-----	1.39
Sep 2005	76,108,173	8	0.38	5	0.11	0	-----	2	0.36	7	0.14	1	<0.01	0	-----	2.24
May 2006	217,281,884	6	1.00	1	<0.01	0	-----	1	<0.01	1	<0.01	0	-----	0	-----	1.13
Jun 2006	93,779,718	3	0.76	7	0.05	0	-----	1	0.14	0	-----	1	<0.01	1	0.05	1.13
Jul 2006	397,827,012	6	0.87	4	0.02	2	0.01	1	0.07	2	<0.01	2	0.03	0	-----	0.77
Aug 2006	123,147,584	2	0.61	6	0.07	0	-----	1	0.14	1	0.01	2	<0.01	1	0.17	1.66
Oct 2006	577,387,603	8	0.88	1	<0.01	0	-----	1	0.01	2	0.06	3	0.04	0	-----	1.22
May 2007	111,867,224	11	0.69	3	0.17	1	0.06	1	0.08	0	-----	0	-----	0	-----	1.44
June 2007	119,135,131	8	0.65	5	0.13	2	0.15	1	0.07	0	-----	0	-----	0	-----	1.64
July 2007	204,517,663	6	0.72	6	0.07	1	0.03	1	0.09	2	0.01	1	0.07	0	-----	1.67
Aug 2007	157,266,490	6	0 26	7	0.17	2	0.01	1	0.10	3	0.01	1	0.46	0	-----	1.61
Sep 2007	229,575,999	7	0.54	5	0.06	1	<0.01	2	0.03	5	0.02	1	0.35	0	-----	1.66
Mean*	**177,580,677**	**5.76**	**0.65**	**3.47**	**0.08**	**0.59**	**0.07**	**1.47**	**0.14**	**2.29**	**0.05**	**0 94**	**0.12**	**0.12**	**0.11**	**1.57**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 82. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Garrison Reservoir at site GARLK1445DW during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	1,685,612	3	0.62	0	-----	0	-----	1	0.21	3	0.17	0	-----	0	-----	1.46
Jul 2004	184,759,537	7	0 97	0	-----	0	-----	2	0.03	2	<0.01	0	-----	0	-----	1.07
Aug 2004	286,075,340	5	0.88	4	0.01	1	0.01	1	0.05	8	0.03	2	0.03	0	-----	1.44
Sep 2004	155,608,125	6	0.73	7	0.22	0	-----	1	0.03	4	0.02	1	<0.01	1	<0.01	1.81
Jun 2005	117,713,953	3	0.66	3	0.21	0	-----	2	0.11	4	0.01	1	<0.01	0	-----	1.50
Jul 2005	72,156,390	5	0.46	2	<0.01	1	0.23	1	0.08	3	0.01	1	0.23	0	-----	1.65
Aug 2005	355,699,437	6	0.73	2	0.05	1	0.01	2	0.07	8	0.15	0	-----	0	-----	1.71
Sep 2005	177,778,515	1	0.08	5	0.36	0	-----	1	0.04	8	0.50	2	0.03	0	-----	1.64
May 2006	494,273,807	7	0.99	1	<0.01	0	-----	2	<0.01	1	<0.01	0	-----	0	-----	1.18
Jun 2006	49,254,498	8	0.73	5	0.08	1	0.02	1	0.17	0	-----	0	-----	0	-----	2.02
Jul 2006	271,528,998	3	0.73	5	0.01	1	<0.01	1	0.22	3	0.03	1	<0.01	0	-----	1.31
Aug 2006	252,320,396	4	0.81	4	0.05	0	-----	1	0.07	1	0.05	1	0.02	0	-----	1.40
Oct 2006	360,297,717	7	0.51	12	0.36	0	-----	1	0.04	6	0.08	1	0.01	0	-----	2.00
May 2007	4,434,931,365	12	0.98	5	0.02	0	-----	1	<0.01	0	-----	0	-----	0	-----	0.59
June 2007	160,826,868	8	0.73	9	0.19	0	-----	2	0.05	0	-----	1	0.02	0	-----	1.45
July 2007	305,880,416	7	0.80	7	0.04	1	0.04	1	0.05	3	0.05	1	0.03	0	-----	1.13
Aug 2007	215,286,031	6	0.34	8	0.16	0	-----	1	0.15	3	<0.01	1	0.33	1	0.01	1.92
Sep 2007	253,797,184	8	0.80	10	0.06	0	-----	1	0.02	4	0.01	1	0.12	0	-----	1.76
Mean*	**452,770,788**	**5.89**	**0.70**	**4.94**	**0.11**	**0.33**	**0.05**	**1.28**	**0.08**	**3.39**	**0.07**	**0.78**	**0.07**	**0.11**	**<0.01**	**1.50**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 83. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Garrison Reservoir at site GARLK1481DW during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	641,406,981	7	0.95	1	<0.01	0	-----	2	0.04	4	<0.01	1	<0.01	1	<0.01	1.24
Jul 2004	143,415,460	10	0.65	1	<0.01	0	-----	2	0.34	4	<0.01	0	-----	1	<0.01	1.67
Aug 2004	116,129,651	6	0.94	3	0.01	0	-----	2	0.02	1	<0.01	2	0.03	0	-----	1.41
Sep 2004	212,398,576	8	0.77	11	0.10	0	-----	2	0.09	4	0.03	2	<0.01	1	0.01	2.03
Jun 2005	162,736,064	4	0.48	6	0.24	0	-----	2	0.23	3	0.01	1	0.03	1	<0.01	2.06
Jul 2005	45,637,096	3	0 95	3	0.04	0	-----	1	0.01	1	<0.01	0	-----	0	-----	1.26
Aug 2005	123,071,200	4	0.52	6	0.13	0	-----	2	0.16	5	0.05	2	0.14	0	-----	1.80
Sep 2005	136,453,161	10	0.30	10	0.47	0	-----	2	0.10	8	0.07	1	0.04	1	0.02	2.07
May 2006	350,014,023	10	0.90	9	0.03	2	0.01	1	<0.01	1	<0.01	2	0.04	3	0.01	2.06
Jun 2006	271,464,027	8	0.96	4	0.02	0	-----	1	<0.01	1	0.01	0	-----	1	<0.01	0.99
Jul 2006	109,852,109	7	0.29	7	0.11	1	0.02	1	0.49	3	0.05	1	0.03	0	-----	1.96
Aug 2006	226,689,591	8	0.36	13	0.25	1	0.01	1	0.06	3	0.26	2	0.05	3	0.02	2.69
Oct 2006	1,395,049,142	10	0.78	17	0.05	2	0.03	2	0.01	6	0.12	2	0.01	2	0.01	2.16
May 2007	2,999,852,220	11	0.89	7	0.11	0	-----	1	0.01	0	-----	0	-----	0	-----	0.93
June 2007	513,050,143	10	0.87	7	0.10	0	-----	1	0.02	1	<0.01	0	-----	0	-----	1.29
July 2007	254,413,324	9	0 13	6	0.11	1	<0.01	1	0.13	4	0.62	1	0.02	0	-----	2.01
Aug 2007	222,884,487	8	0.33	8	0.16	1	<0.01	1	0.15	5	0.03	1	0.32	2	0.01	2.05
Sep 2007	918,618,938	10	0.82	12	0.04	1	0.01	2	0.01	4	0.06	2	0.04	2	0.02	2.02
Mean*	**491,285,344**	**7.94**	**0.66**	**7.28**	**0.11**	**0.50**	**0.01**	**1.50**	**0.10**	**3.22**	**0.08**	**1 11**	**0.06**	**1.0**	**0.01**	**1.76**

* Mean percent composition represents the mean when taxa of that division are present.

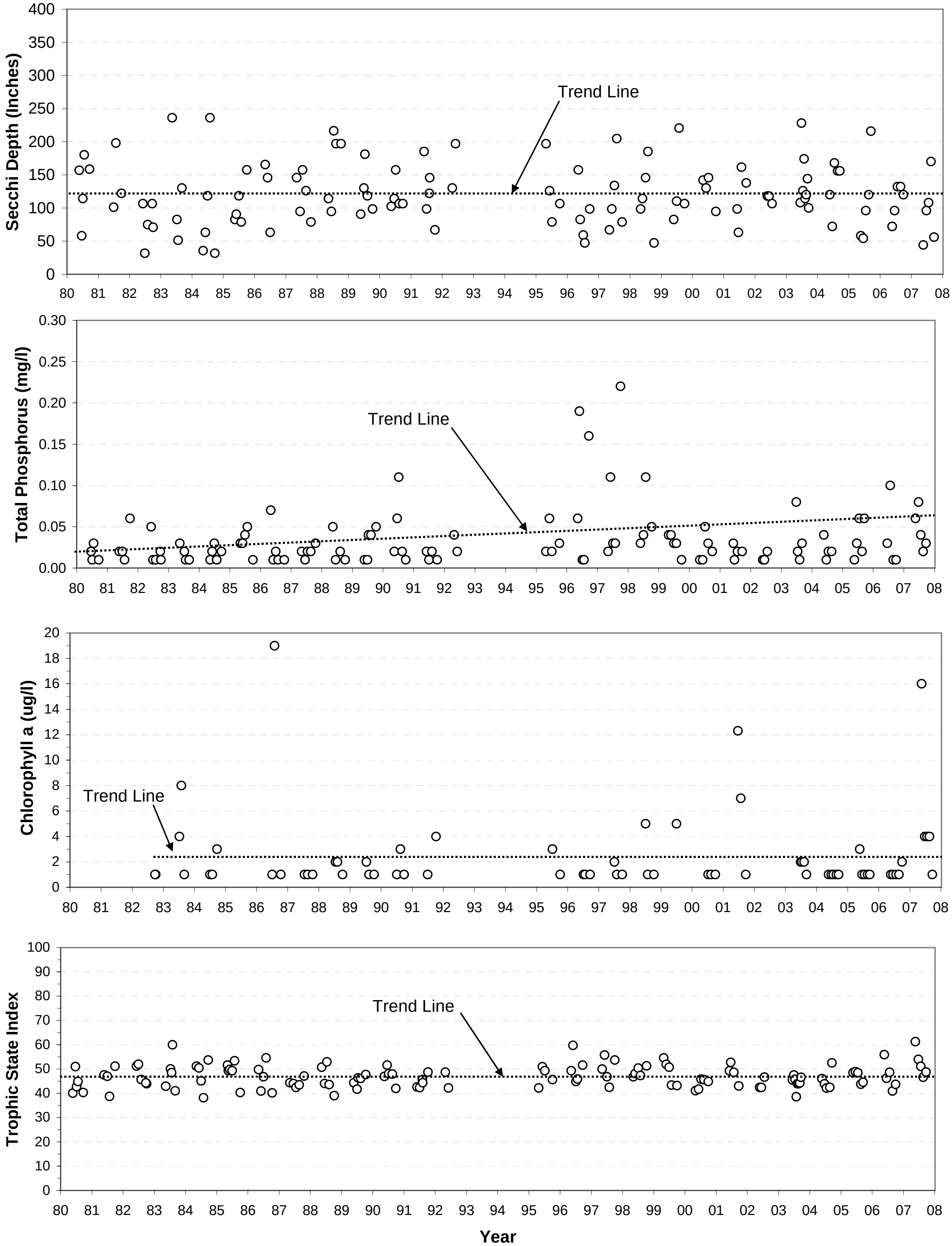


Plate 84. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Garrison Reservoir at the near-dam, ambient site (i.e., site GARLK1390A) over the 28-year period of 1980 to 2007.

Plate 85. Summary of monthly (May through September) water quality conditions monitored in the Missouri River near Williston, North Dakota (Site GARNFMORRR1) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	1	27	16,685	12,010	7,649	38,300	-----	-----	-----
Water Temperature (C)	0.1	27	20.3	21.8	11.5	30.9	29.4(1) 15.0(1)	1 21	4% 78%
Dissolved Oxygen (mg/l)	0.1	27	8.1	7.8	6.8	10.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	27	93.2	92.5	78.1	105.0	-----	-----	-----
Specific Conductance (umho/cm)	1	27	536	564	292	744	-----	-----	-----
pH (S.U.)	0.1	27	8.4	8.3	7.9	8.7	≥7.0 & ≤9.0	0	0%
Alkalinity, Total (mg/l)	7	27	144	151	89	188	-----	-----	-----
Ammonia, Total (mg/l)	0.01	26	-----	0.07	n.d.	0.72	3.15 (2,3), 0.92 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	26	2.9	2.7	1.5	4.3	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	12	13	11	5	33	-----	-----	-----
Chloride (mg/l)	1	11	8	8	4	14	100	0	0%
Dissolved Solids, Total (mg/l)	5	26	376	385	217	542	-----	-----	-----
Hardness, Total (mg/l)	0.4	2	218	218	205	231	-----	-----	-----
Iron, Dissolved (ug/l)	40	18	-----	n.d.	n.d.	50	-----	-----	-----
Iron, Total (ug/l)	40	17	7,635	4,214	1,979	32,066	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	26	0.7	0.6	0.1	1.8	-----	-----	-----
Manganese, Dissolved (ug/l)	1	18	4	2	n.d.	30	-----	-----	-----
Manganese, Total (ug/l)	1	17	173	91	54	629	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	27	-----	n.d,	n.d.	0.28	1	0	0%
Phosphorus, Dissolved (mg/l)	0.01	27	-----	0.02	n.d.	0.18	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	27	0.25	0.16	0.04	1.00	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	27	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	27	139	147	64	194	-----	-----	-----
Suspended Solids, Total (mg/l)	4	27	244	119	37	1,196	-----	-----	-----
Aluminum, Dissolved (ug/l)	5	1	5	5	5	5	750(3)	0	0%
Antimony, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	0.6	5.6(5)	0	0%
Arsenic, Dissolved (ug/l)	1	2	-----	1	n.d.	2	340(3), 150(4), 10(5)	0	0%
Barium, Dissolved (ug/l)	5	1	51	51	51	51	1,000	0	0%
Beryllium, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	4(5)	0	0%
Cadmium, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	4.7(3), 0.5(4), 5(5)	0	0%
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	3,414(3), 163(4), 100(5)	0	0%
Copper, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	3	29.2(3), 18.2(4), 1,000(5)	0	0%
Lead, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	220(3), 8.6(4), 15(5)	0	0%
Mercury, Dissolved (ug/l)	0.02	2	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.02	2	-----	n.d.	n.d.	n.d.	1.7(3), 0.012(4), 0.05(5)	0, b.d., 0	0%, b.d , 0%
Nickel, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	907(3), 101(4), 100(5)	0	0%
Selenium, Total (ug/l)	1	2	-----	n.d.	n.d.	1	20(3), 5(4), 50(5)	0	0%
Silver, Dissolved (ug/l)	1	2	-----	n.d.	n.d.	n.d.	13.7(3)	0	0%
Thallium, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	0.24(5)	b.d.	b.d.
Zinc, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	232(3,4), 7,400(5)	0	0%
Pesticide Scan (ug/l)***	0.05	2	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected. b.d. = Criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

(5) Human health value.

Note: North Dakota's criteria for metals are based on total recoverable, most metals were analyzed for dissolved. Listed criteria are given for comparison and were calculated using the median hardness value.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides do not have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

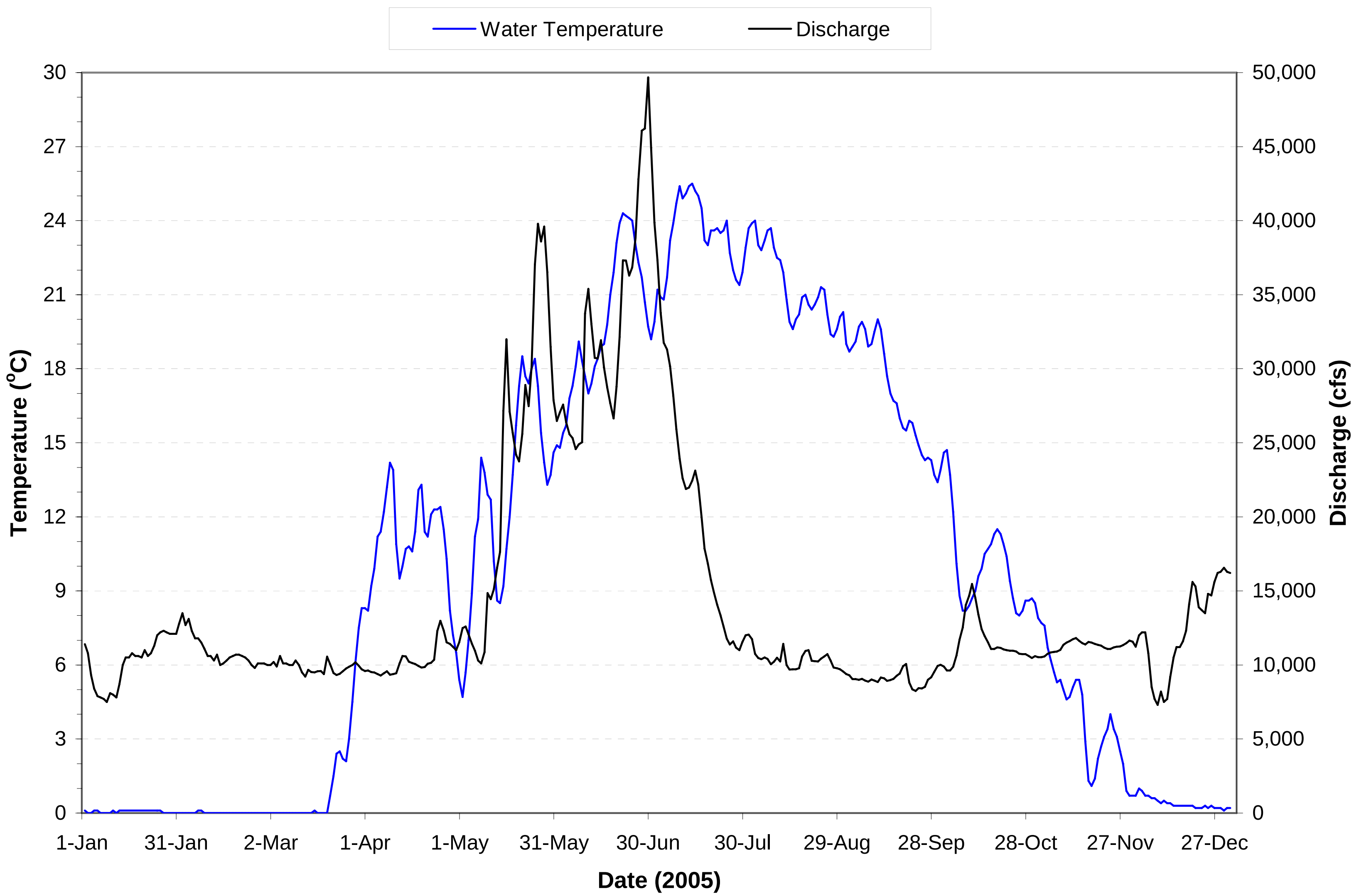


Plate 86. Mean daily water temperature and discharge of the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) for 2005. Mean temperatures based on hourly measurements recorded on the Missouri River near Williston, North Dakota (USGS gaging station 06330000). Mean daily discharge estimated by adding mean daily discharge recorded for the Missouri River near Culbertson, Montana (USGS gaging station 06185500) and the mean daily discharge recorded for the Yellowstone River near Sidney, Montana (USGS gaging station 06329500).

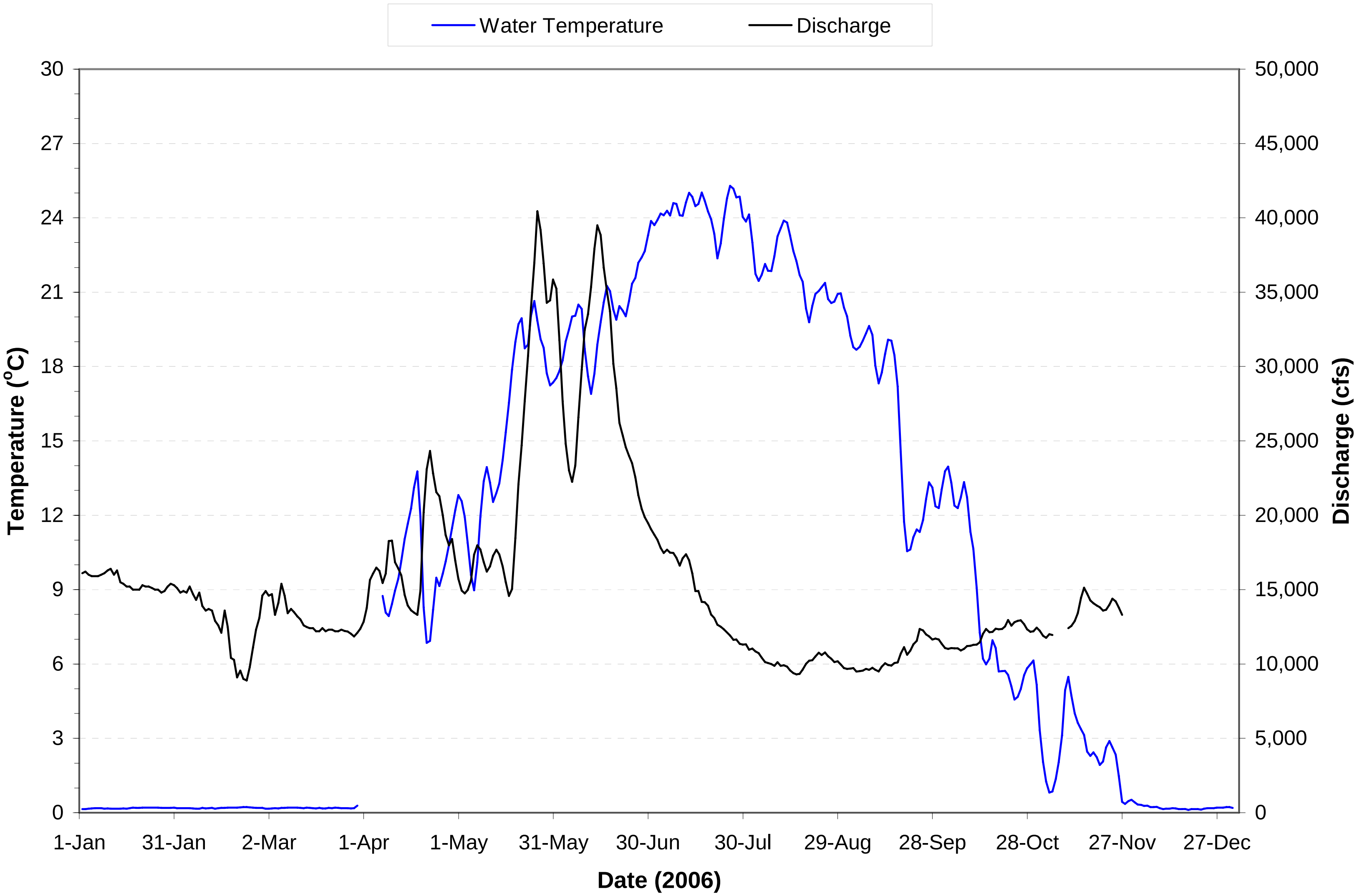


Plate 87. Mean daily water temperature and discharge of the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) for 2006. Mean temperatures based on hourly measurements recorded on the Missouri River near Williston, North Dakota (USGS gaging station 06330000). Mean daily discharge estimated by adding mean daily discharge recorded for the Missouri River near Culbertson, Montana (USGS gaging station 06185500) and the mean daily discharge recorded for the Yellowstone River near Sidney, Montana (USGS gaging station 06329500).

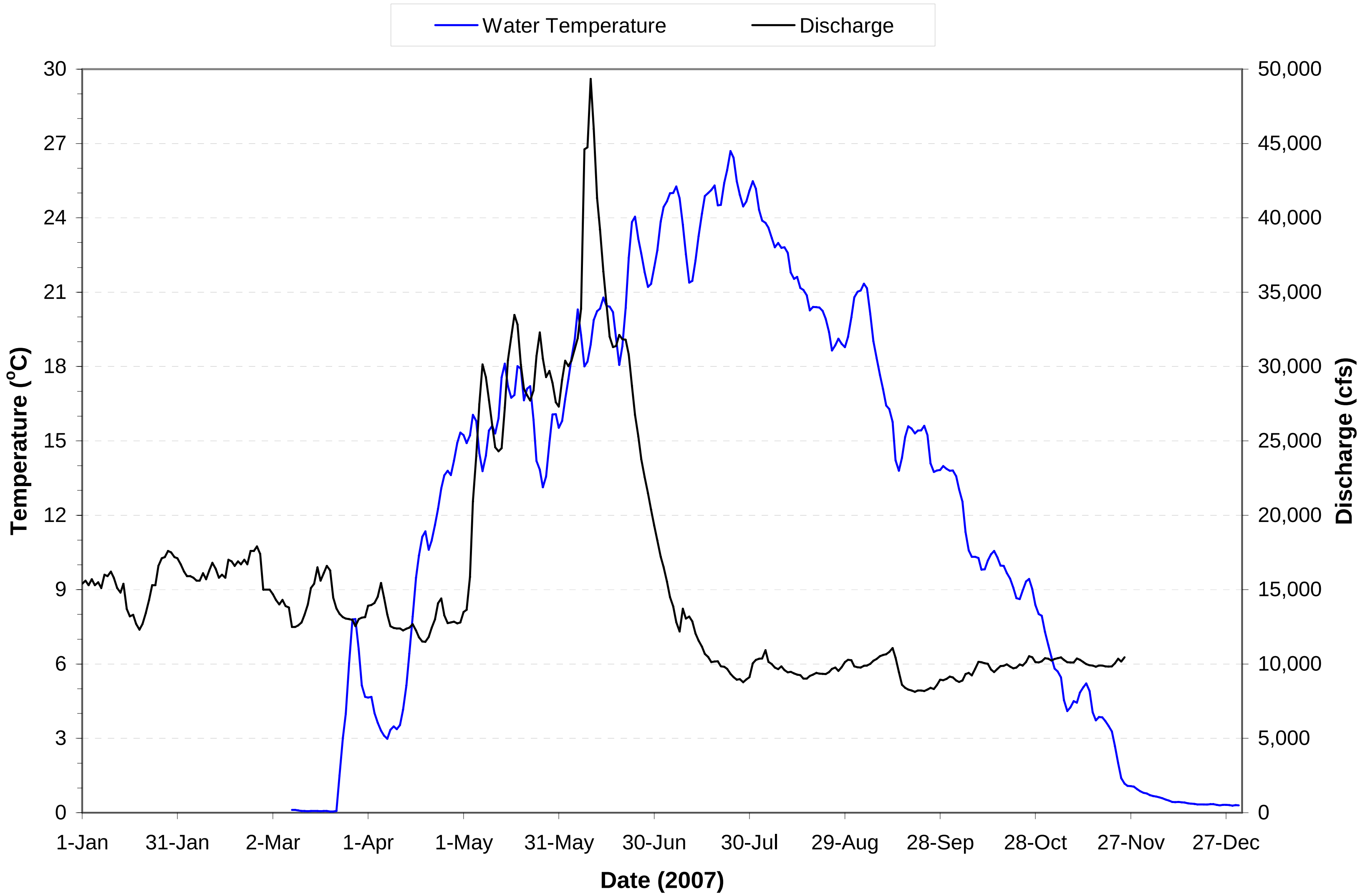


Plate 88. Mean daily water temperature and discharge of the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) for 2007. Mean temperatures based on hourly measurements recorded on the Missouri River near Williston, North Dakota (USGS gaging station 06330000). Mean daily discharge estimated by adding mean daily discharge recorded for the Missouri River near Culbertson, Montana (USGS gaging station 06185500) and the mean daily discharge recorded for the Yellowstone River near Sidney, Montana (USGS gaging station 06329500).

Plate 89. Summary of water quality conditions monitored on water discharged through Garrison Dam (i.e., site GARPP1) during the 1½-year period of June 2003 through December 2004.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	**No. of Obs.**	**Mean***	**Median**	**Min.**	**Max.**	**State WQS Criteria****	**No. of WQS Exceedences**	**Percent WQS Exceedence**
Dam Discharge (cfs)	1	13,509	16,632	14,970	4,830	34,380	-----	-----	-----
Water Temperature (C)	0.1	12,427	8.8	10.2	0.2	19.0	29.4[(1)] 15.0[(1)]	0 1,078	0% 9%
Dissolved Oxygen (mg/l)	0.1	11,593	9.2	9.0	3.9	15.1	≥ 5.0	3	<1%
Dissolved Oxygen (% Sat.)	0.1	16	78.1	79.8	44.6	99.0	-----	-----	-----
Specific Conductance (umho/cm)	1	14	597	611	522	659	-----	-----	-----
pH (S.U.)	0.1	16	8.1	8.1	7.4	8.8	≥7.0 & ≤9.0	0	0%
Oxidation-Reduction Potential (mV)	1	14	450	439	316	601	-----	-----	-----
Alkalinity, Total (mg/l)	7	14	167	166	155	182	-----	-----	-----
Ammonia, Total (mg/l)	0.01	13	0.29	0.37	n.d.	0.66	4.64 [(2,3)], 2.52 [(2,4)]	0	0%
Carbon, Total Organic (mg/l)	0.05	14	3.0	2.9	2.7	4.6	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	14	422	403	370	530	-----	-----	-----
Hardness, Total (mg/l)	0.4	1	205	205	205	205	-----	-----	-----
Iron, Dissolved (ug/l)	40	9	-----	n.d.	n.d.	112	-----	-----	-----
Iron, Total (ug/l)	40	11	191	148	100	451	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	13	0.7	0.7	0.2	1.6	-----	-----	-----
Manganese, Dissolved (ug/l)	1	10	-----	n.d.	n.d.	8	-----	-----	-----
Manganese, Total (ug/l)	1	11	11	9	n.d.	43	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	14	0.09	1.10	n.d.	0.18	1	0	0%
Phosphorus, Dissolved (mg/l)	0.01	12	-----	0.02	n.d.	0.14	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	14	-----	0.03	n.d.	0.21	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	14	-----	n.d.	n.d.	0.09	-----	-----	-----
Sulfate (mg/l)	1	14	164	161	146	188	-----	-----	-----
Suspended Solids, Total (mg/l)	4	14	-----	n.d.	n.d.	12	-----	-----	-----
Antimony, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	6[(5)]	0	0%
Arsenic, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	340[(3)], 150[(4)], 50[(5)]	0	0%
Beryllium, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	4[(5)]	0	0%
Cadmium, Dissolved (ug/l)	0.2	1	-----	n.d.	n.d.	n.d.	10.2[(3)], 4 3[(4)], 5[(5)]	0	0%
Chromium, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	3,246[(3)], 155[(4)], 100[(5)]	0	0%
Copper, Dissolved (ug/l)	2	1	-----	n.d.	n.d.	n.d.	27.5[(3)], 17.2[(4)], 1,000[(5)]	0	0%
Lead, Dissolved (ug/l)	0.5	1	-----	n.d.	n.d.	n.d.	204[(3)], 7.9[(4)], 15[(5)]	0	0%
Mercury, Dissolved (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	-----	0	0%
Mercury, Total (ug/l)	0.02	1	-----	n.d.	n.d.	n.d.	1.7[(3)], 0.91[(4)], 0.05[(5)]	0	0%
Nickel, Dissolved (ug/l)	10	1	-----	n.d.	n.d.	n.d.	861[(3)], 9678[(4)], 100[(5)]	0	0%
Selenium, Total (ug/l)	1	1	-----	n.d.	n.d.	n.d.	20[(3)], 5[(4)], 50[(5)]	0	0%
Silver, Dissolved (ug/l)	1	1	-----	n.d.	n.d.	n.d.	14.7	0	0%
Zinc, Dissolved (ug/l)	10	1	6	6	6	6	220[(3,4)], 9,100[(5)]	0	0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

(5) Human health value.

Note: North Dakota's criteria for metals are based on total recoverable, most metals were analyzed for dissolved. Listed criteria are given for comparison and were calculated using the median hardness value.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 90. Summary of water quality conditions monitored on water discharged through Garrison Dam (i.e., site GARPP1) during the 3-year period of 2005 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	30	17,389	15,100	9,530	37,300	-----	-----	-----
Water Temperature (C)	0.1	29	8.7	8.2	1.0	18.2	29.4[(1)] 15.0[(1)]	0 7	0% 24%
Dissolved Oxygen (mg/l)	0.1	28	10.2	11.0	5.2	14.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	28	89.3	93.0	56.0	105.6	-----	-----	-----
Specific Conductance (umho/cm)	1	28	576	581	481	651	-----	-----	-----
pH (S.U.)	0.1	24	8.1	8.1	7.4	8.9	≥7.0 & ≤9.0	0	0%
Alkalinity, Total (mg/l)	7	32	163	165	140	186	-----	-----	-----
Ammonia, Total (mg/l)	0.01	32	-----	n.d.	n.d.	0.23	3.15 [(2,3)], 0.92 [(2,4)]	0	0%
Carbon, Total Organic (mg/l)	0.05	30	3.2	3.1	1.3	7.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	-----	7	n.d.	14	-----	-----	-----
Chloride (mg/l)	1	19	9	9	8	11	100	0	0%
Dissolved Solids, Total (mg/l)	5	32	407	410	236	516	-----	-----	-----
Hardness, Total (mg/l)	0.4	2	205	205	186	223	-----	-----	-----
Iron, Dissolved (ug/l)	40	24	-----	n.d.	n.d.	n.d.	-----	-----	-----
Iron, Total (ug/l)	40	24	1,030	100	n.d.	20,000	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	31	0.4	0.3	n.d.	2.4	-----	-----	-----
Manganese, Dissolved (ug/l)	1	24	-----	2	n.d.	12	-----	-----	-----
Manganese, Total (ug/l)	1	24	-----	7	n.d.	64	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	32	-----	0.06	n.d.	0.15	1	0	0%
Phosphorus, Dissolved (mg/l)	0.01	24	-----	n.d.	n.d.	0.05	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	32	-----	0.02	n.d.	0.30	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	32	-----	n.d.	n.d.	0.25	-----	-----	-----
Sulfate (mg/l)	1	32	164	170	128	190	-----	-----	-----
Suspended Solids, Total (mg/l)	4	32	-----	n.d.	n.d.	21	-----	-----	-----
Aluminum, Dissolved (ug/l)	5	2	-----	n.d.	n.d.	5	750[(3)]	0	0%
Antimony, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	5.6[(5)]	0	0%
Arsenic, Dissolved (ug/l)	1	4	-----	n.d.	n.d.	1	340[(3)], 150[(4)], 10[(5)]	0	0%
Barium, Dissolved (ug/l)	5	1	50	50	50	50	1,000	0	0%
Beryllium, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	4[(5)]	0	0%
Cadmium, Dissolved (ug/l)	0.2	4	-----	n.d.	n.d.	n.d.	4.4[(3)], 0.5[(4)], 5[(5)]	0	0%
Chromium, Dissolved (ug/l)	10	4	-----	n.d.	n.d.	n.d.	3,246[(3)], 155[(4)], 100[(5)]	0	0%
Copper, Dissolved (ug/l)	2	4	-----	n.d.	n.d.	n.d.	27.5[(3)], 17.2[(4)], 1,000[(5)]	0	0%
Lead, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	204[(3)], 7.9[(4)], 15[(5)]	0	0%
Mercury, Dissolved (ug/l)	0.02	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.02	5	-----	n.d.	n.d.	n.d.	1.7[(3)], 0.012[(4)], 0.05[(5)]	0, b.d., 0	0%, b.d , 0%
Nickel, Dissolved (ug/l)	10	4	-----	n.d.	n.d.	n.d.	861[(3)], 96[(4)], 100[(5)]	0	0%
Selenium, Total (ug/l)	1	4	-----	n.d.	n.d.	n.d.	20[(3)], 5[(4)], 50[(5)]	0	0%
Silver, Dissolved (ug/l)	1	4	-----	n.d.	n.d.	n.d.	13.7[(3)]	0	0%
Thallium, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	0.24[(5)]	b.d.	b.d.
Zinc, Dissolved (ug/l)	10	4	-----	n.d.	n.d.	6	220[(3,4)], 7,400[(5)]	0	0%
Pesticide Scan (ug/l)***	0.05	2	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected. b.d. = Criterion below detection limit.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were n.d., mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Numeric temperature criterion given in North Dakota water quality standards is 29.4 C. No specific numeric temperature criteria are identified for coldwater aquatic life; however, ≤15 C has been identified by North Dakota as the temperature needed to support optimal coldwater fishery habitat in Garrison Reservoir.

(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(3) Acute criterion for aquatic life.

(4) Chronic criterion for aquatic life.

(5) Human health value.

Note: North Dakota's criteria for metals are based on total recoverable, most metals were analyzed for dissolved. Listed criteria are given for comparison and were calculated using the median hardness value.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides do not have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

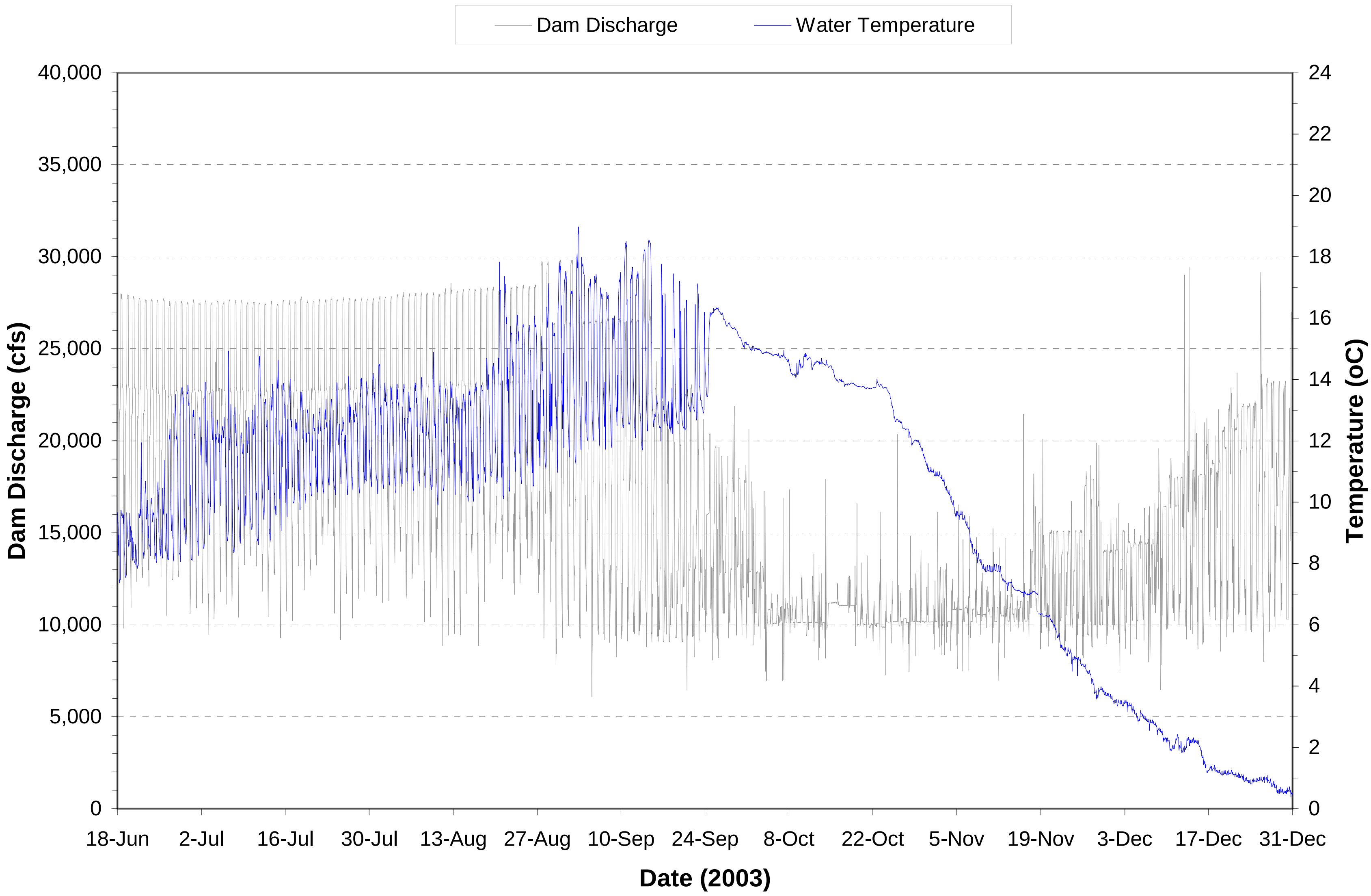


Plate 91. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period June through December 2003. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

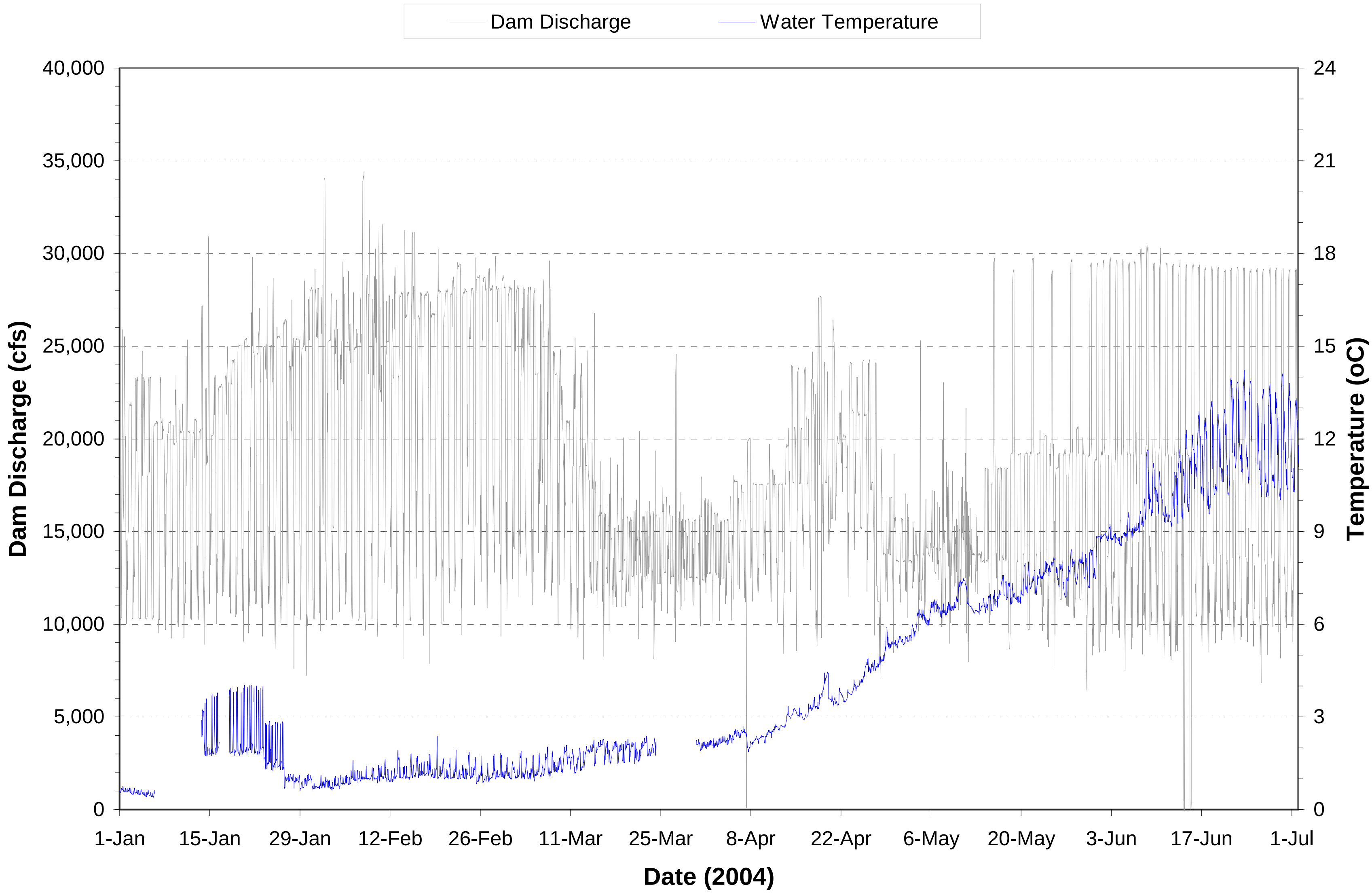


Plate 92. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

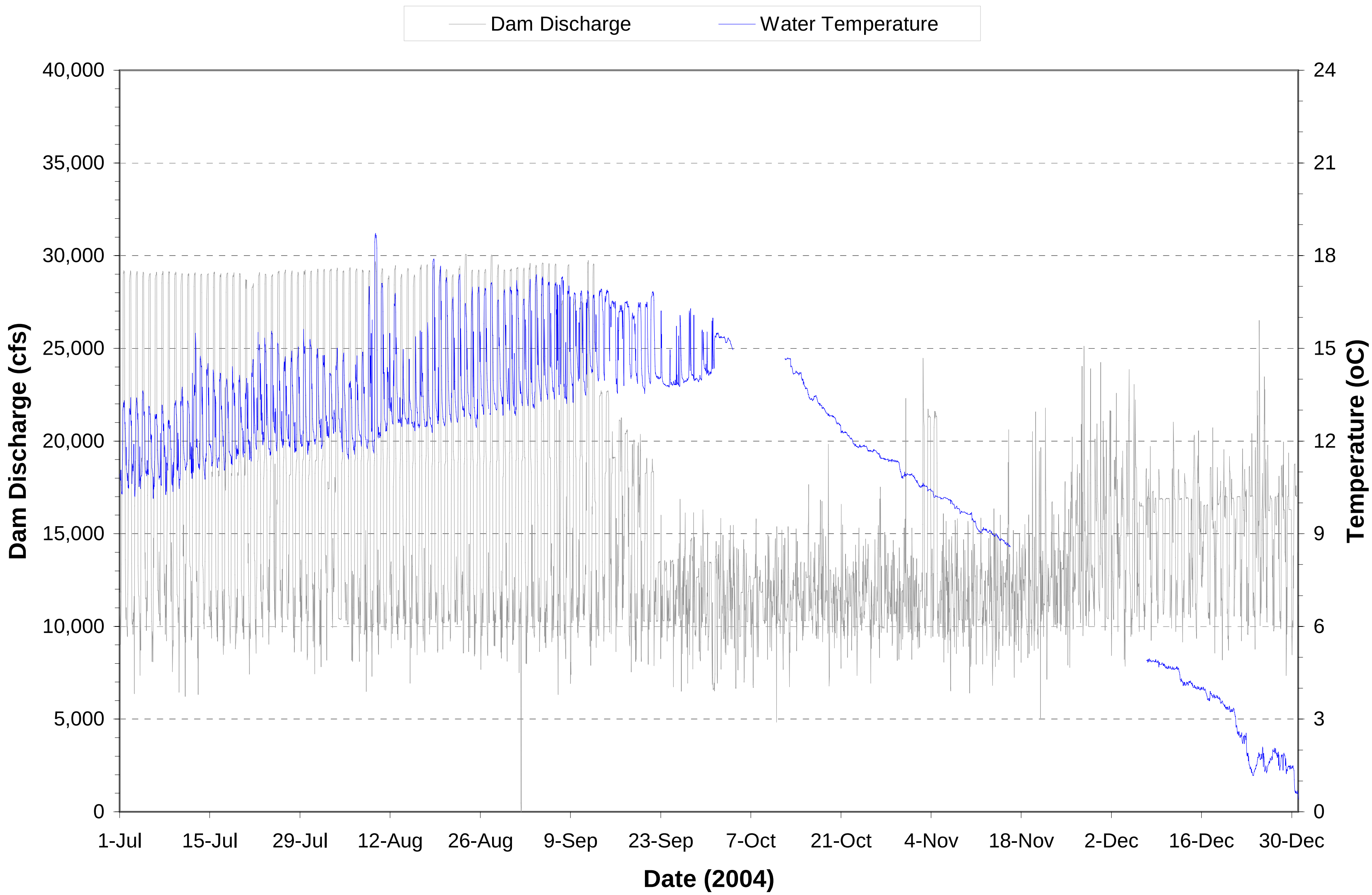


Plate 93. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

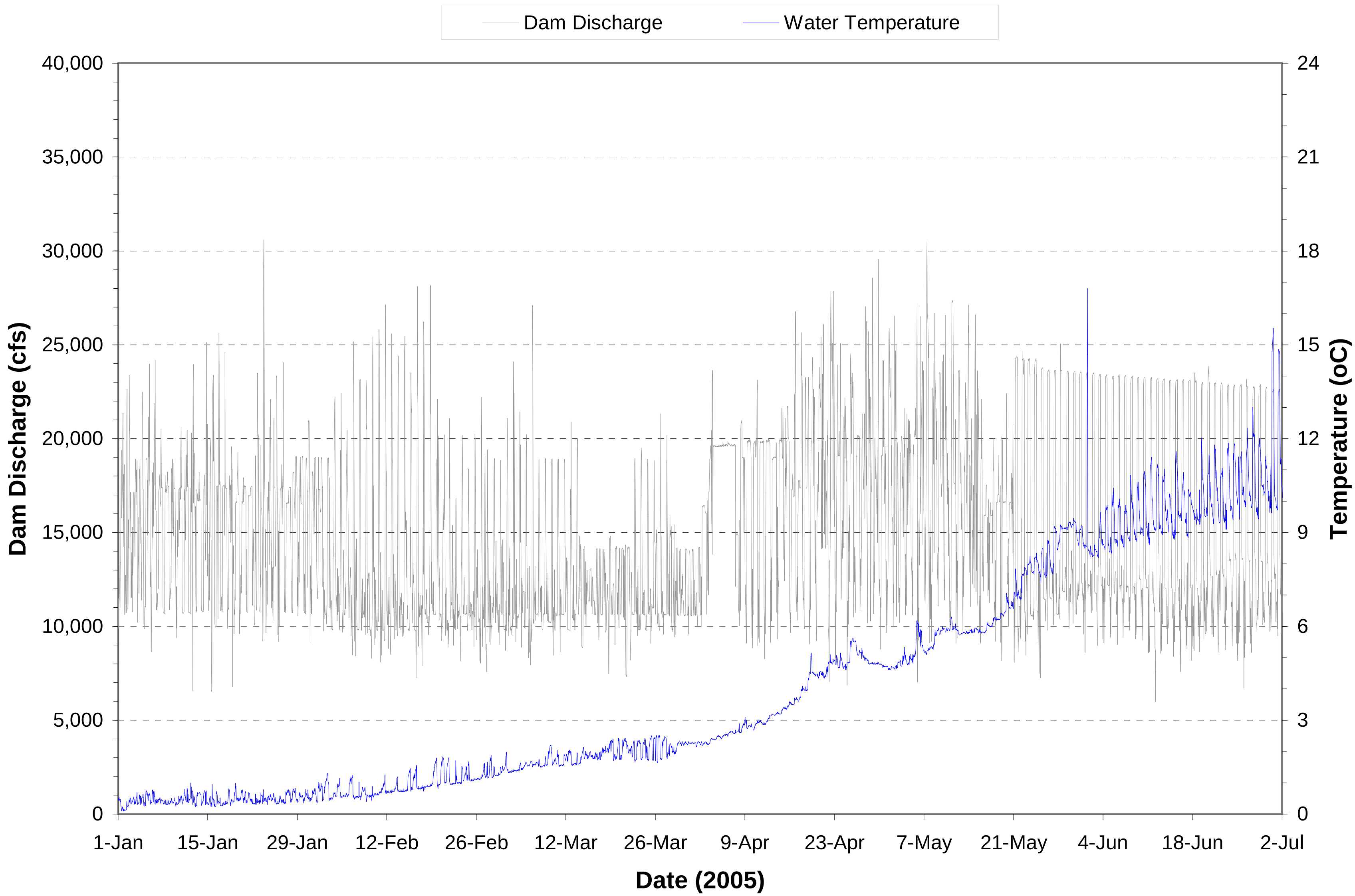


Plate 94. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2005.

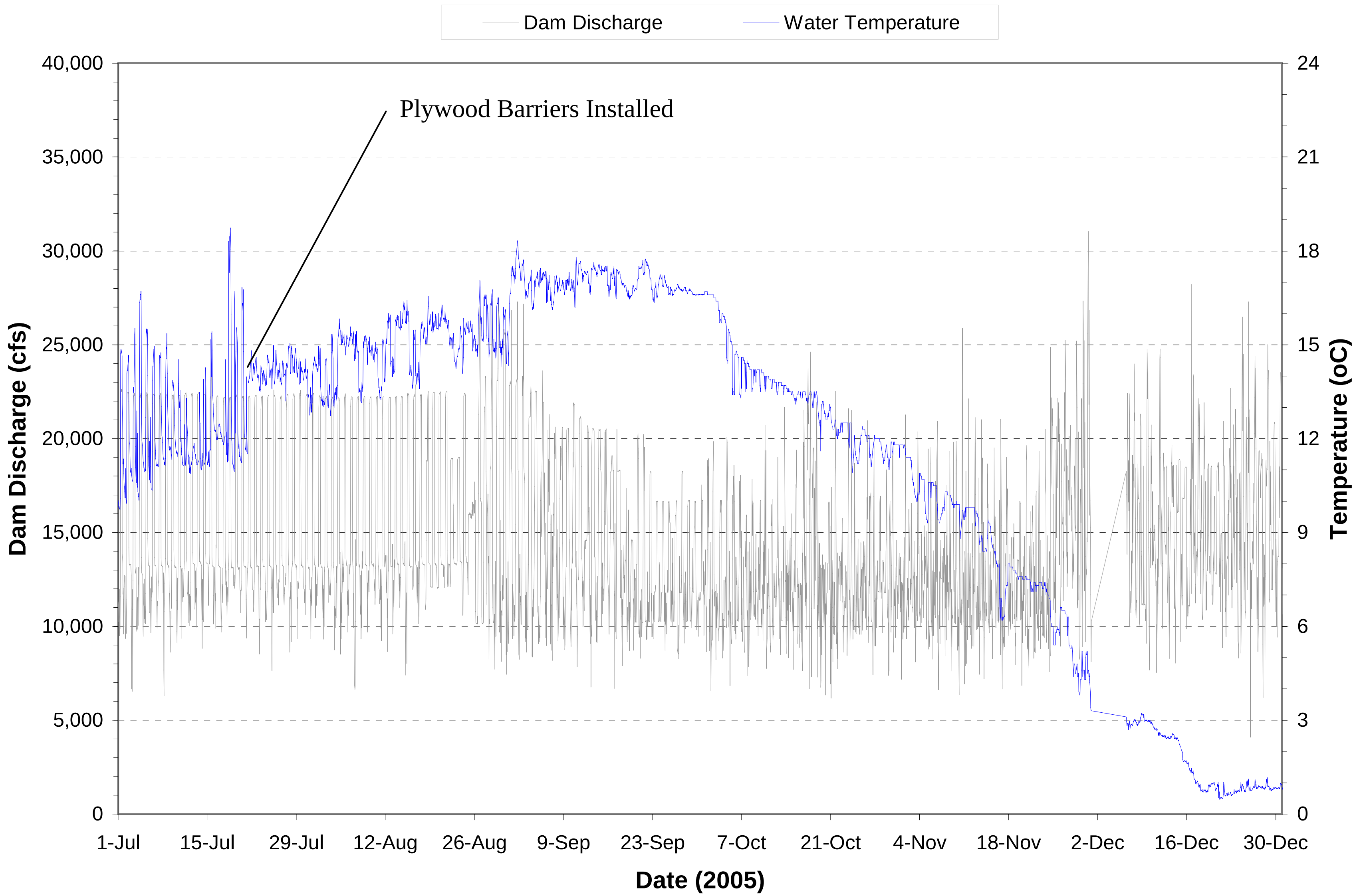


Plate 95. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2005.

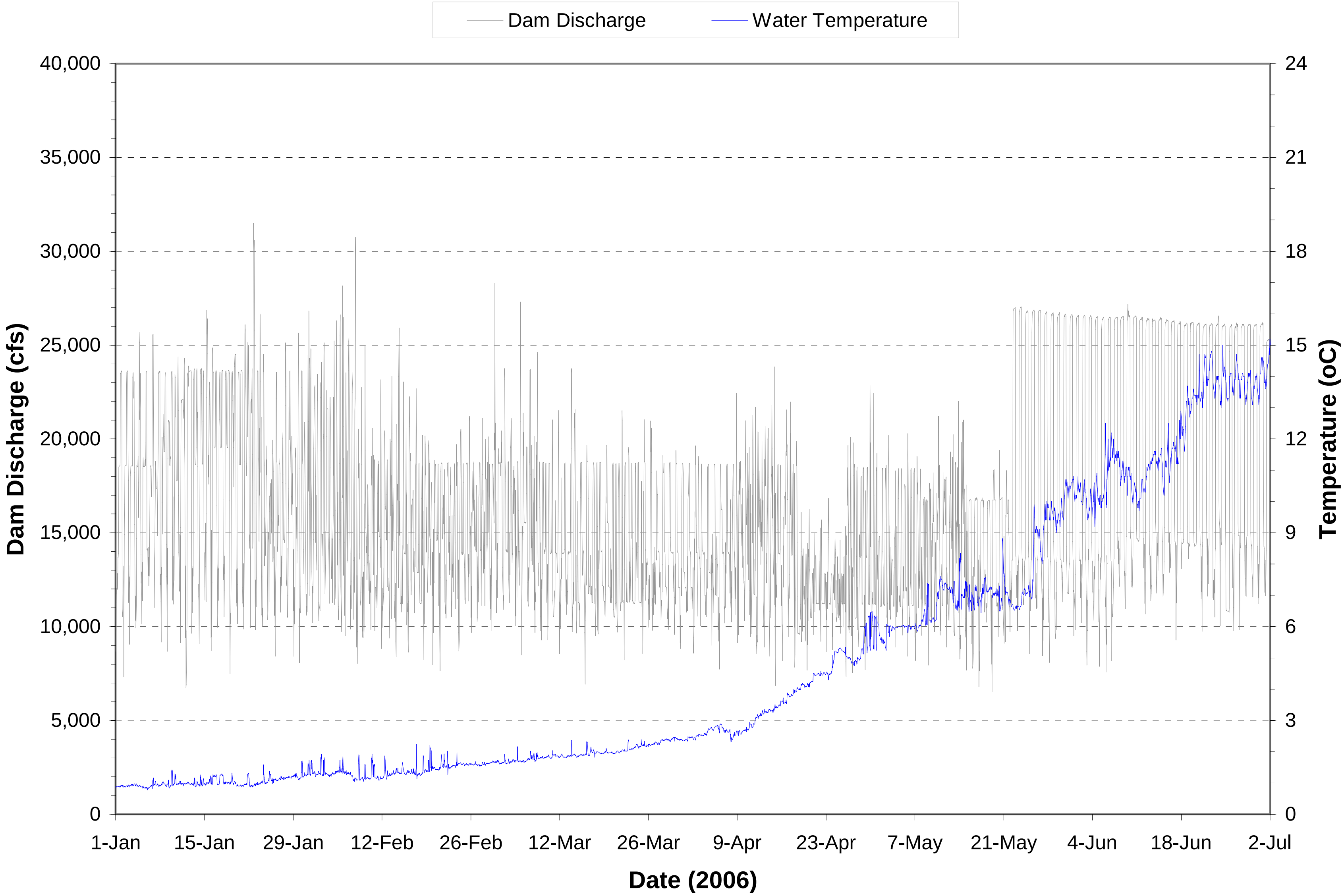


Plate 96. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2006.

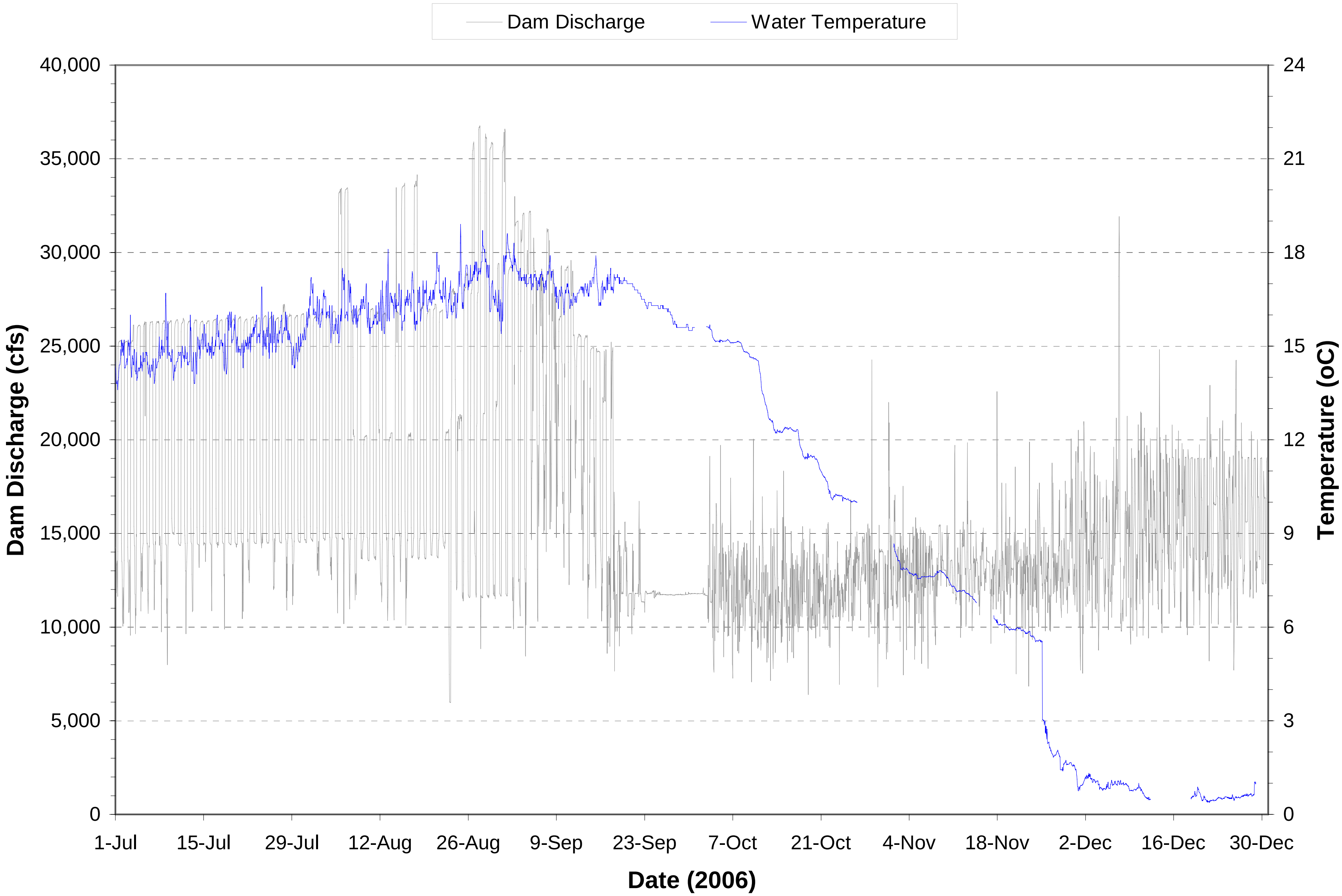


Plate 97. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

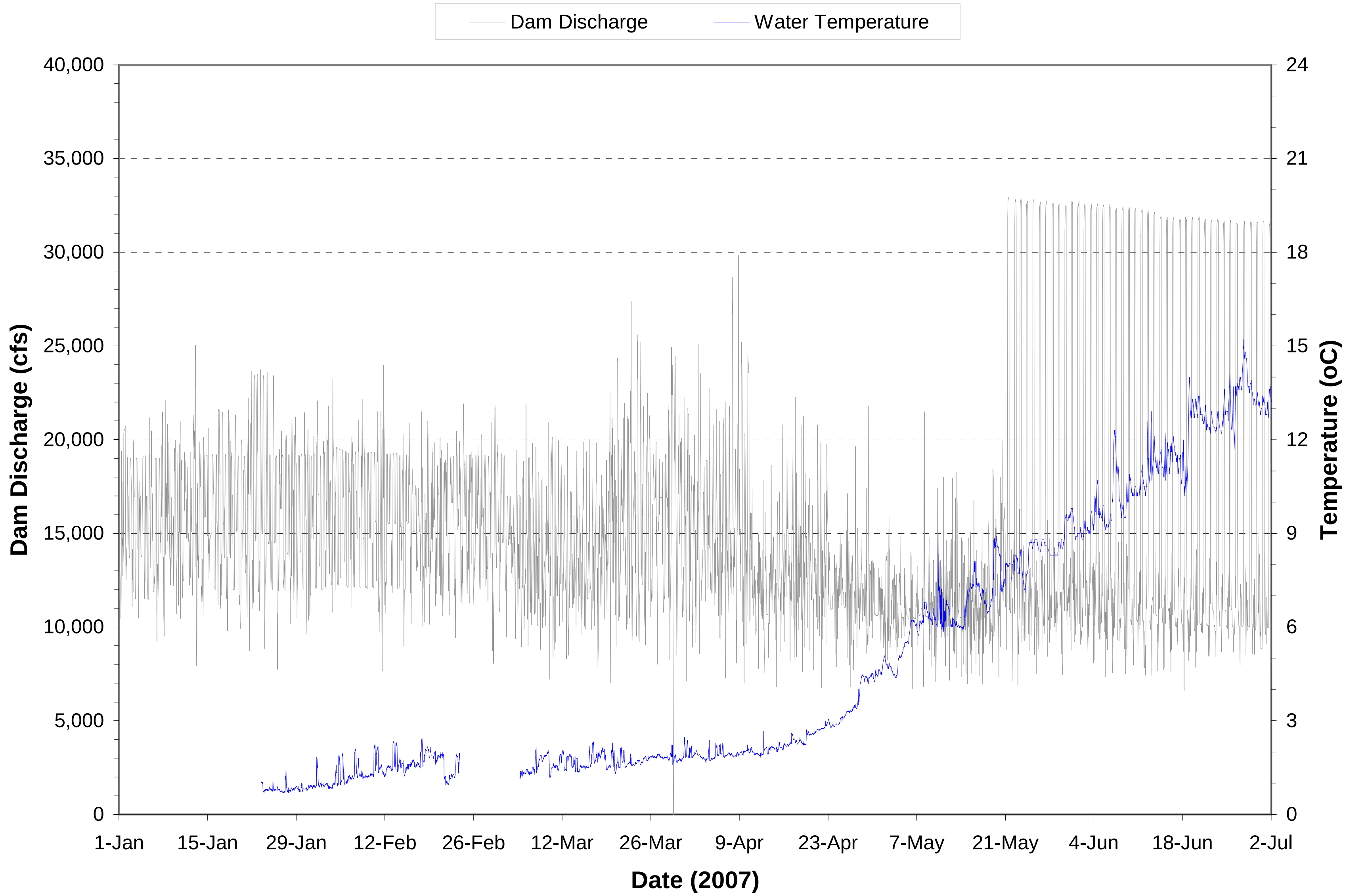


Plate 98. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

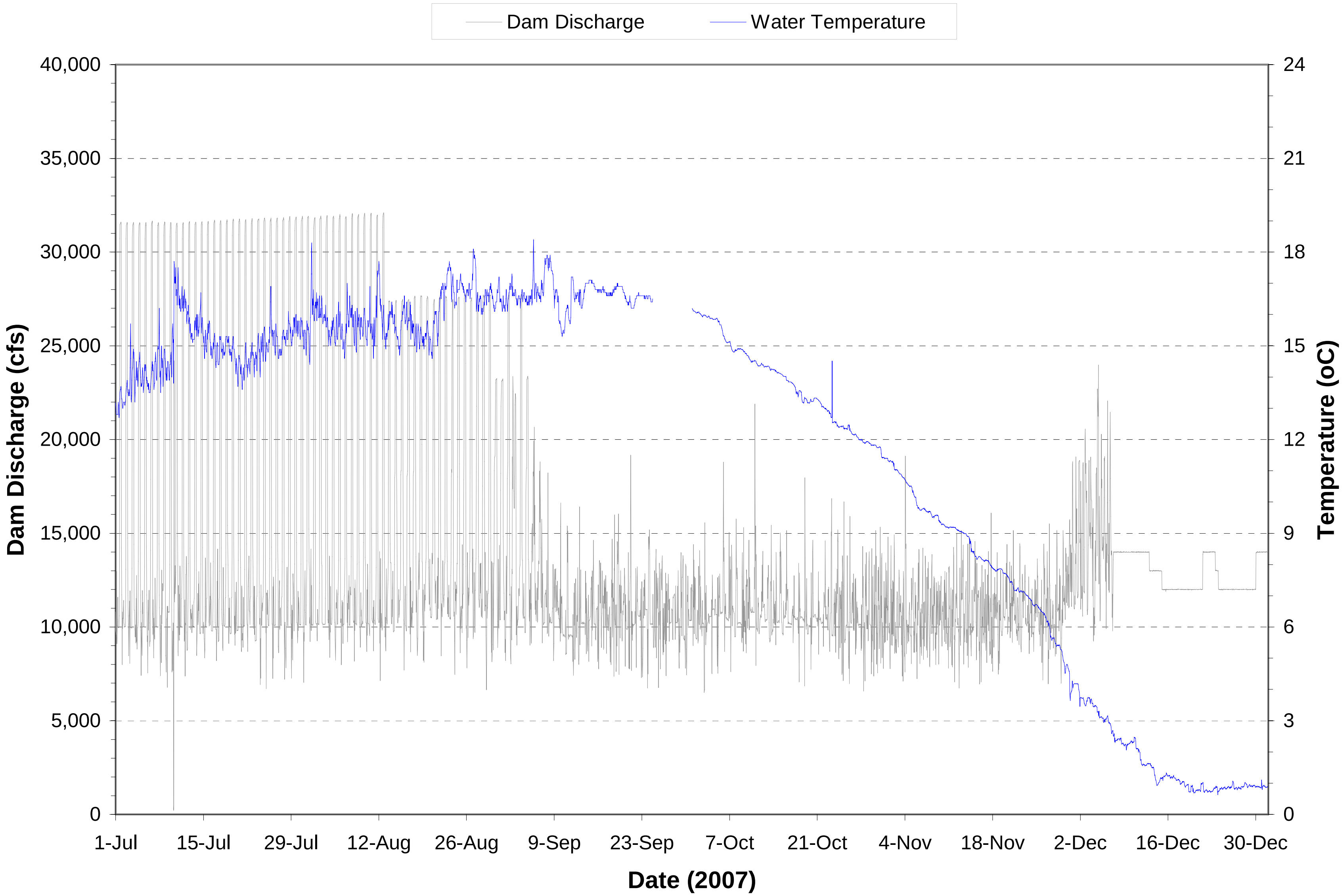


Plate 99. Hourly discharge and water temperature monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

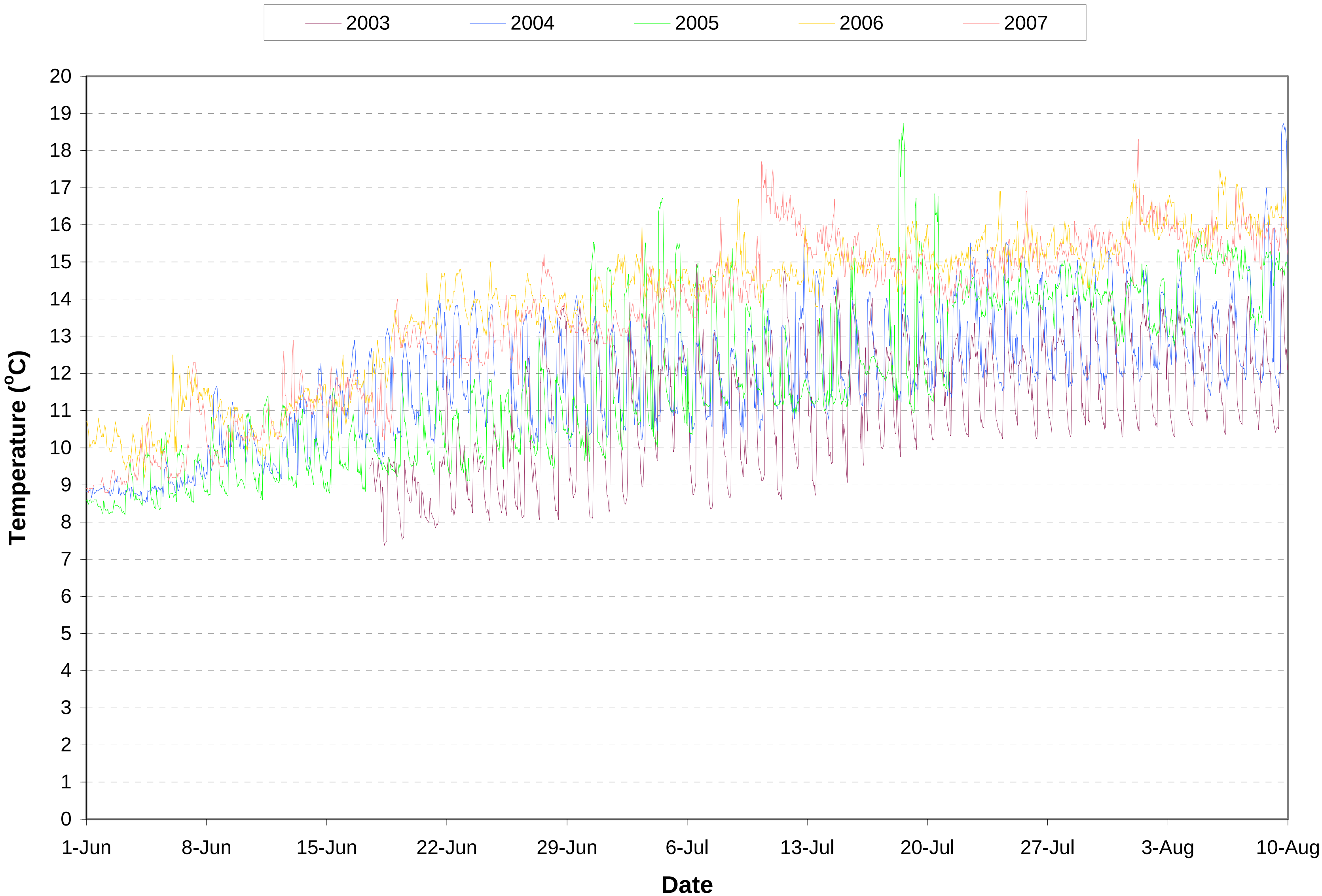


Plate 100. Hourly temperature of water discharged through Garrison Dam during the period June 1 through Mid-August in 2003, 2004, 2005, 2006, and 2007.

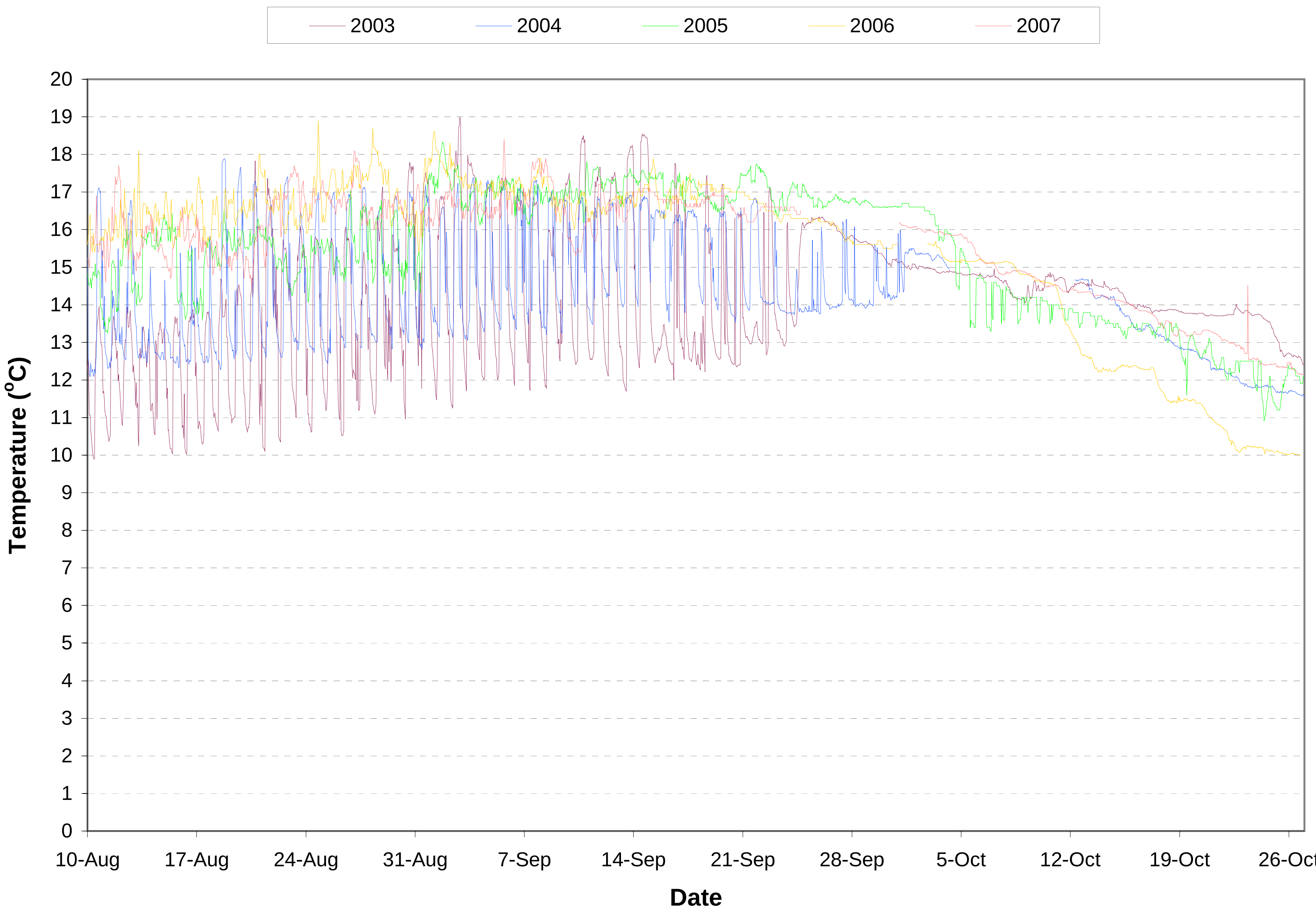


Plate 101. Hourly temperature of water discharged through Garrison Dam during the period Mid-August through October in 2003, 2004, 2005, 2006, and 2007.

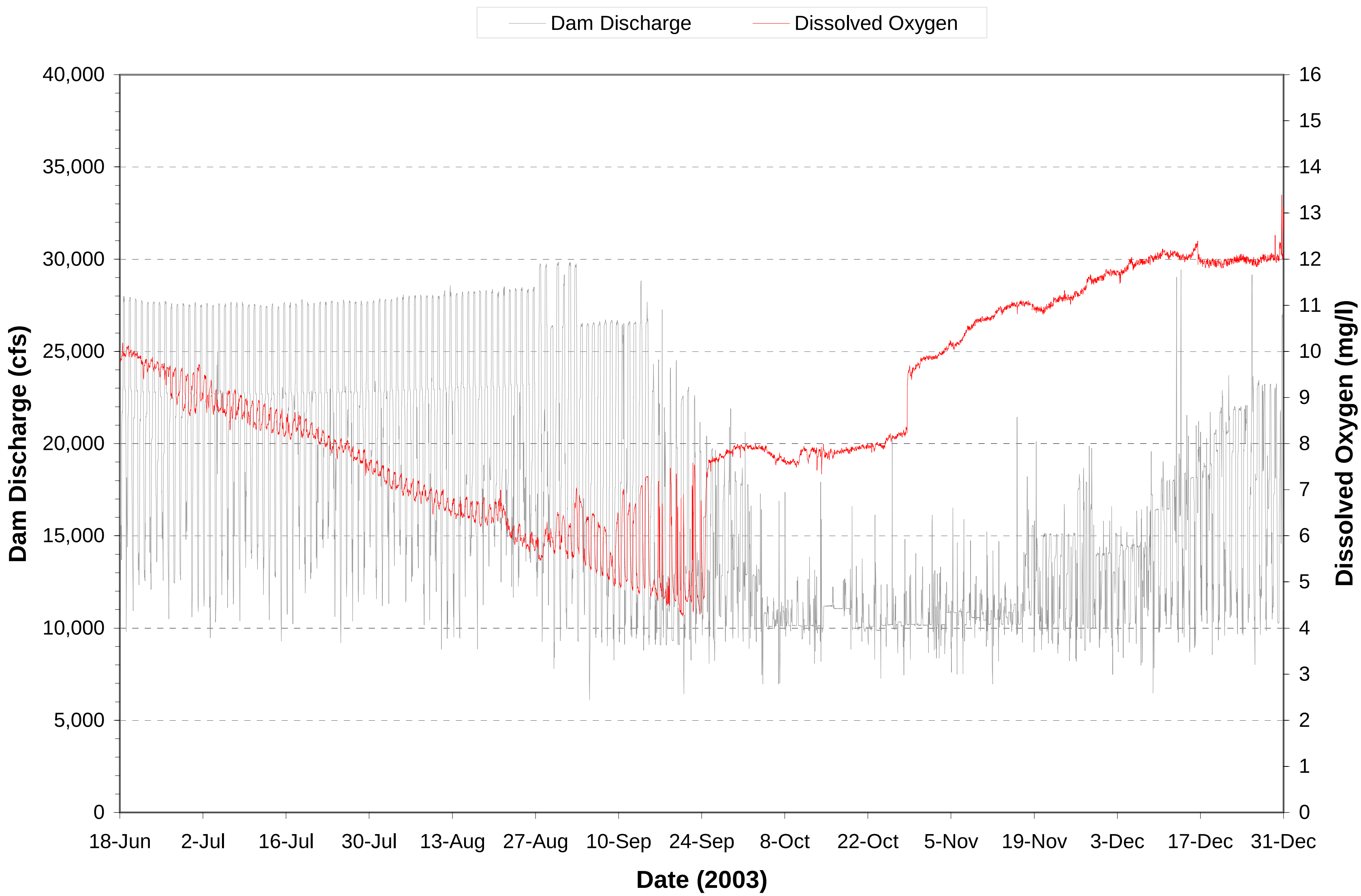


Plate 102. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period June through December 2003.

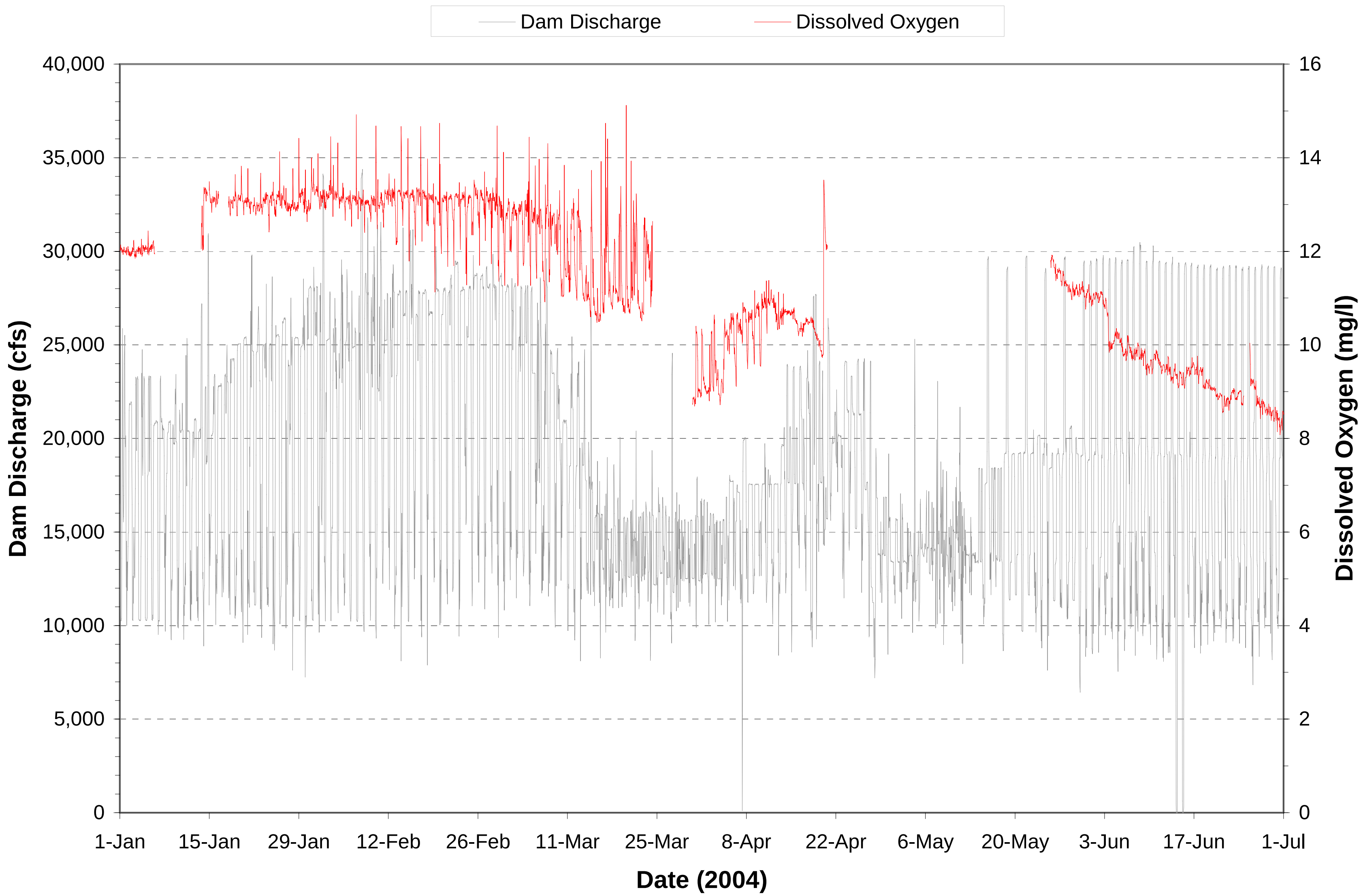


Plate 103. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in dissolved plot represents periods when monitoring equipment was not operational.)

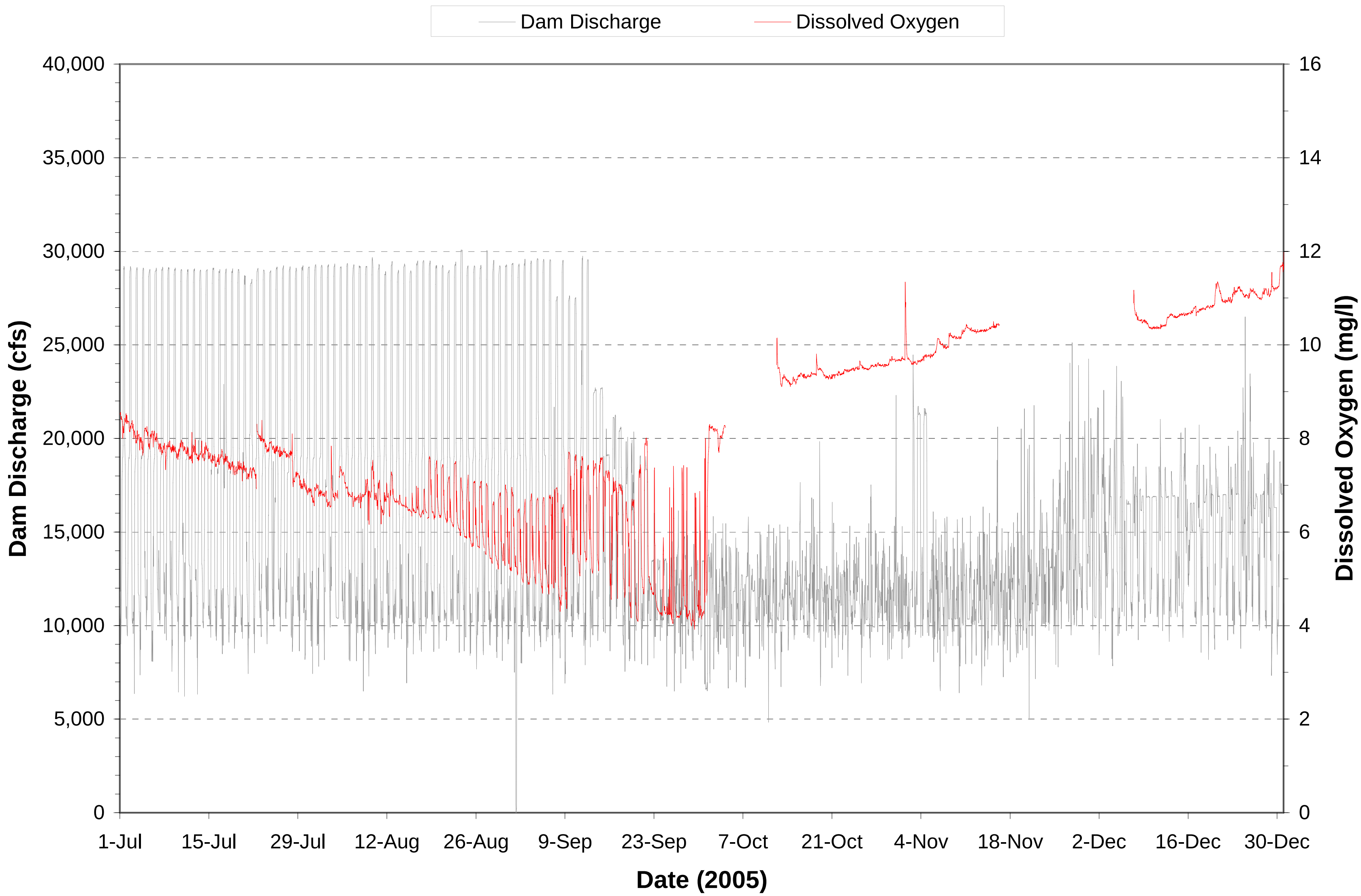


Plate 104. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

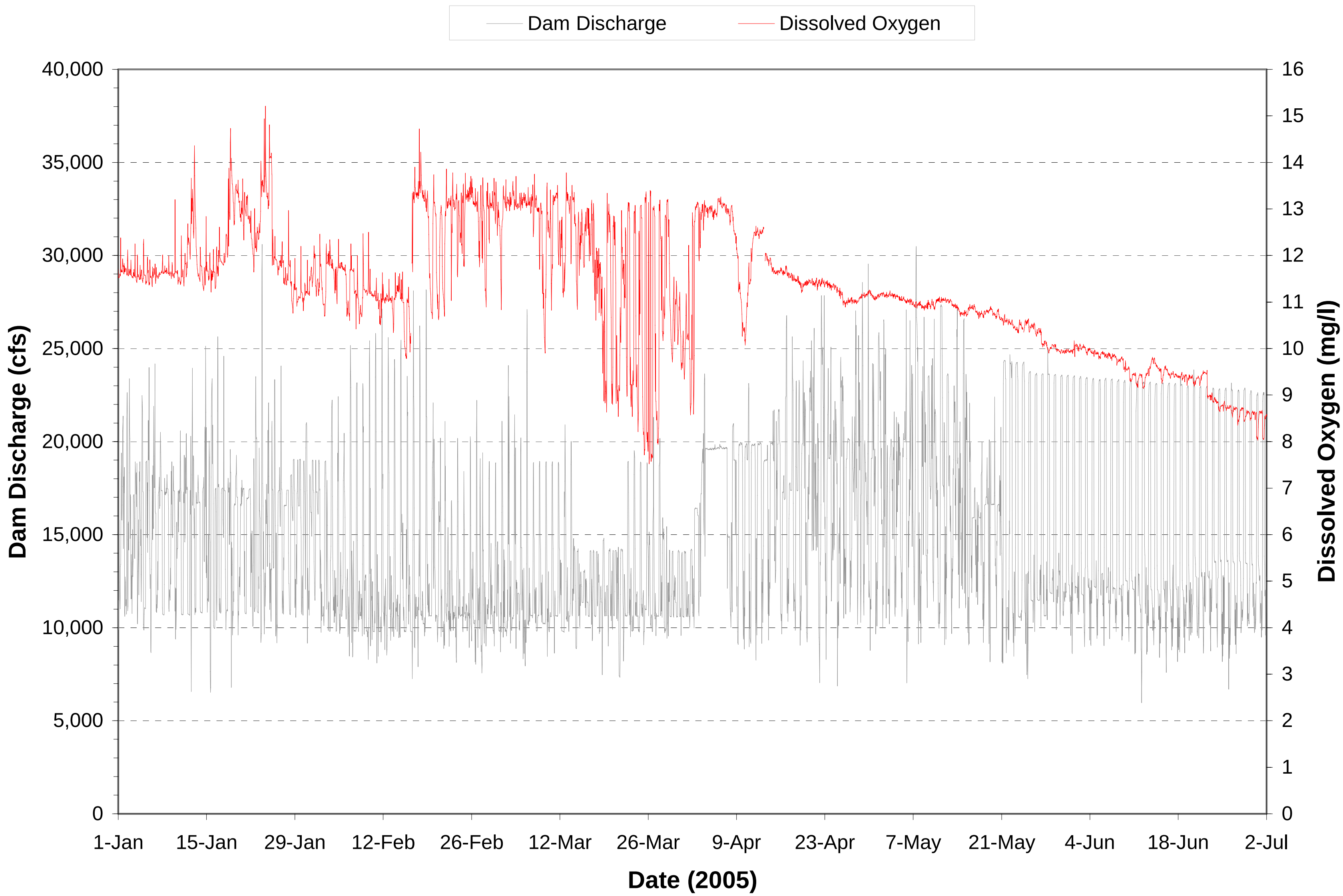


Plate 105. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2005.

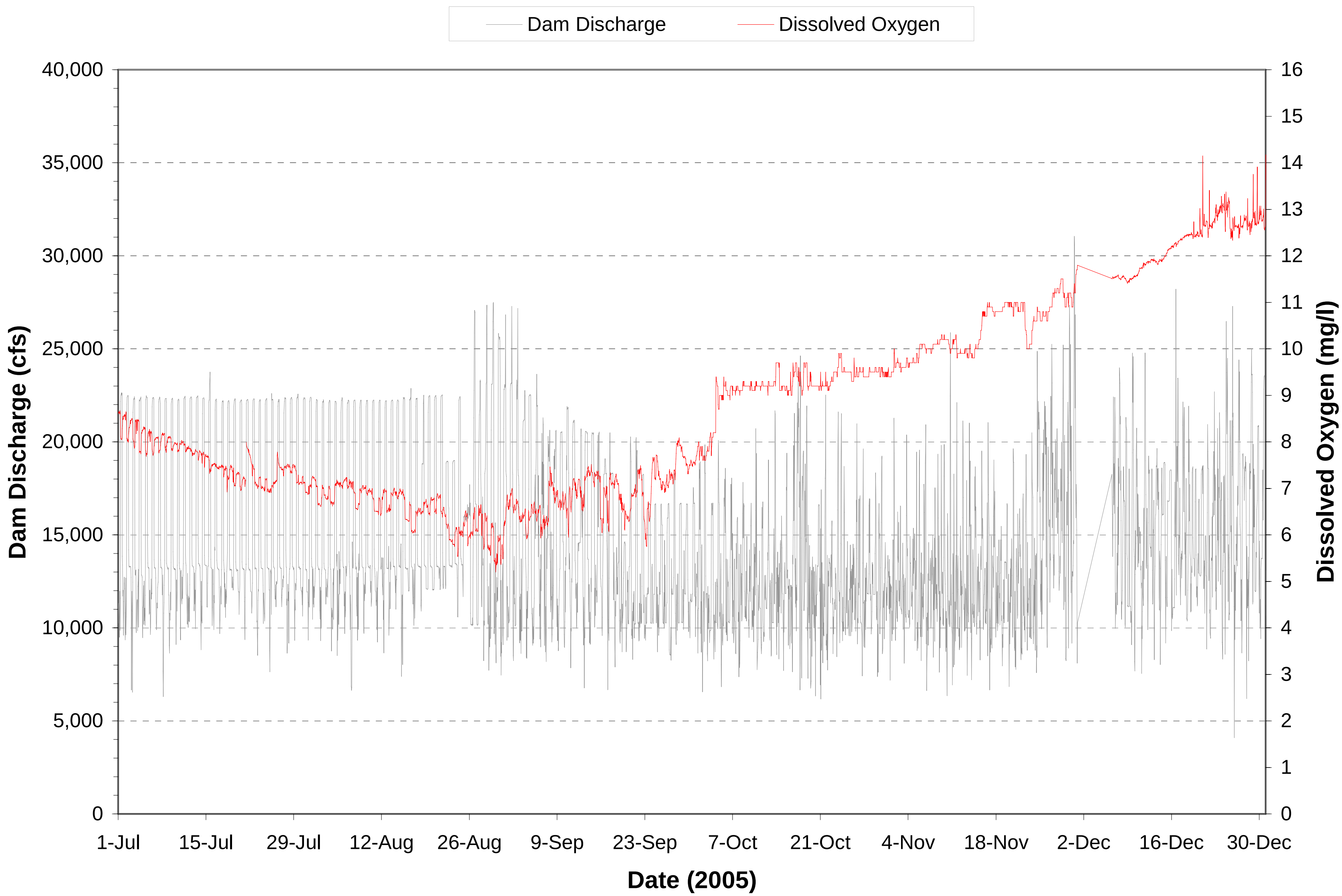


Plate 106. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2005.

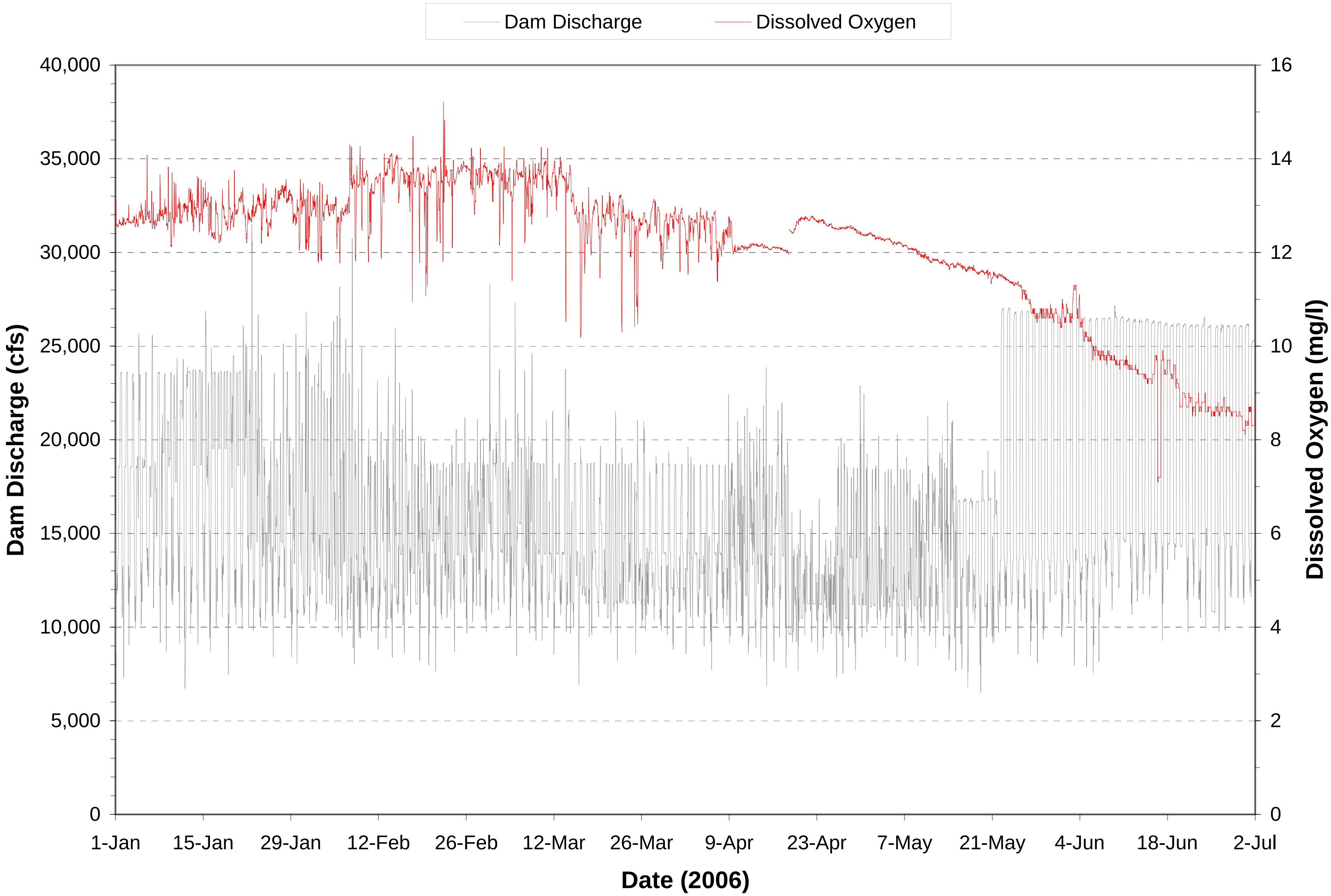


Plate 107. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

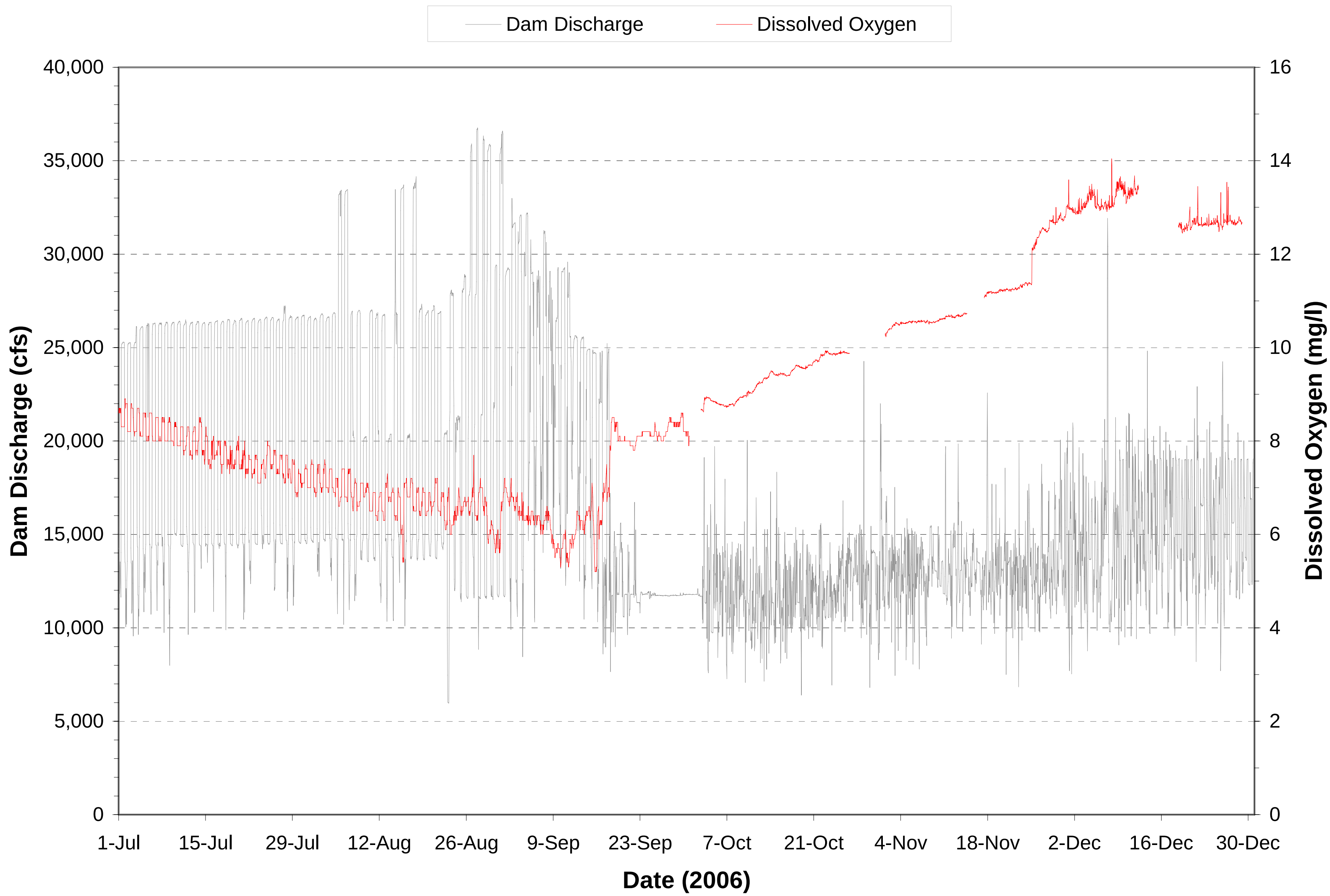


Plate 108. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

Plate 109. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

Plate 110. Hourly discharge and dissolved oxygen monitored at the Garrison powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

Plate 111. Hourly **d**issolved oxygen concentrations of water discharged through Garrison Dam during the period June through mid-August in 2003, 2004, 2005, 2006, and 2007.

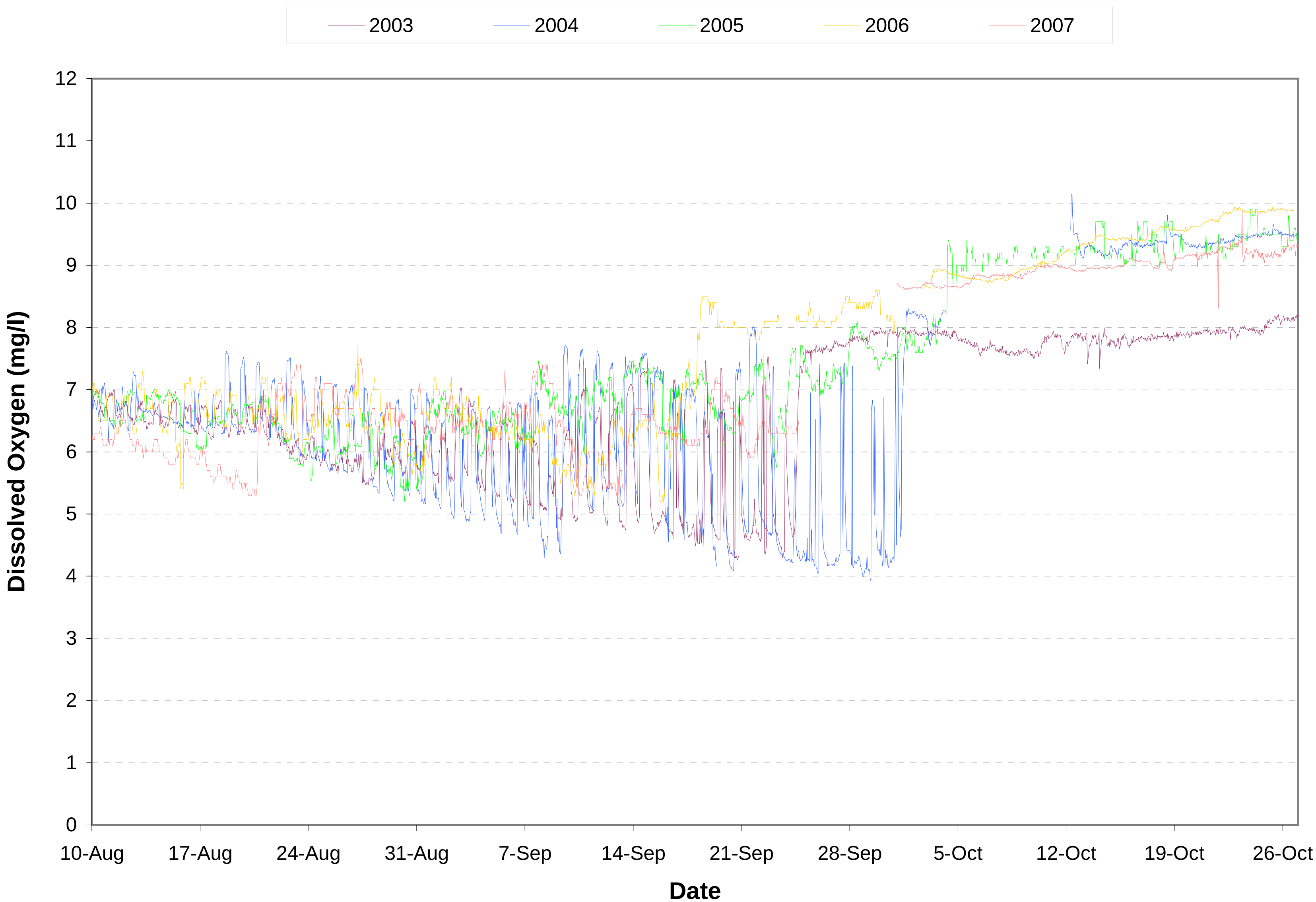


Plate 112. Hourly dissolved oxygen concentrations of water discharged through Garrison Dam during the period mid-August through October in 2003, 2004, 2005, 2006, and 2007.

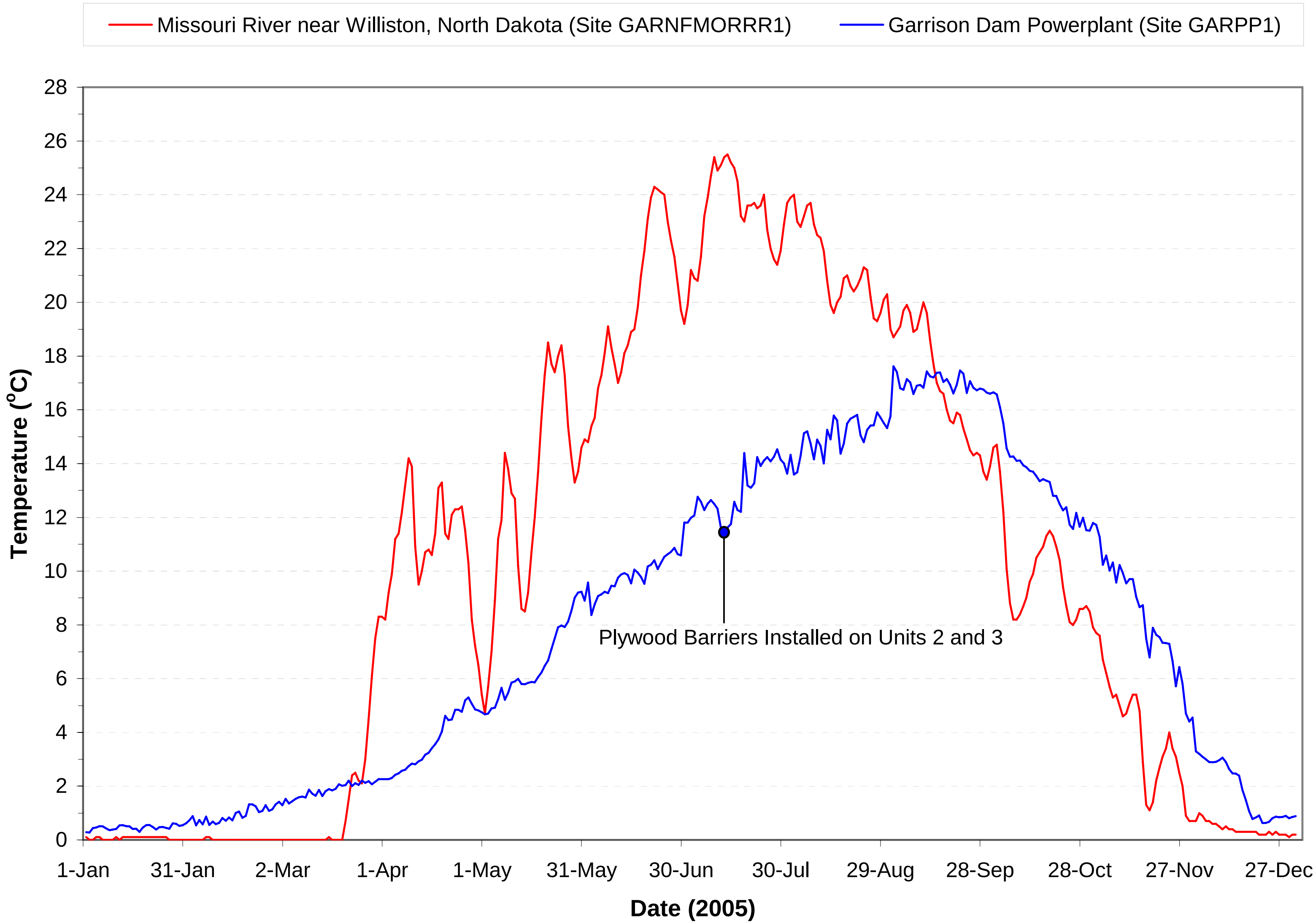


Plate 113. Mean daily water temperatures monitored at the Garrison Powerplant (i.e., site GARPP1) and the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) during 2005.

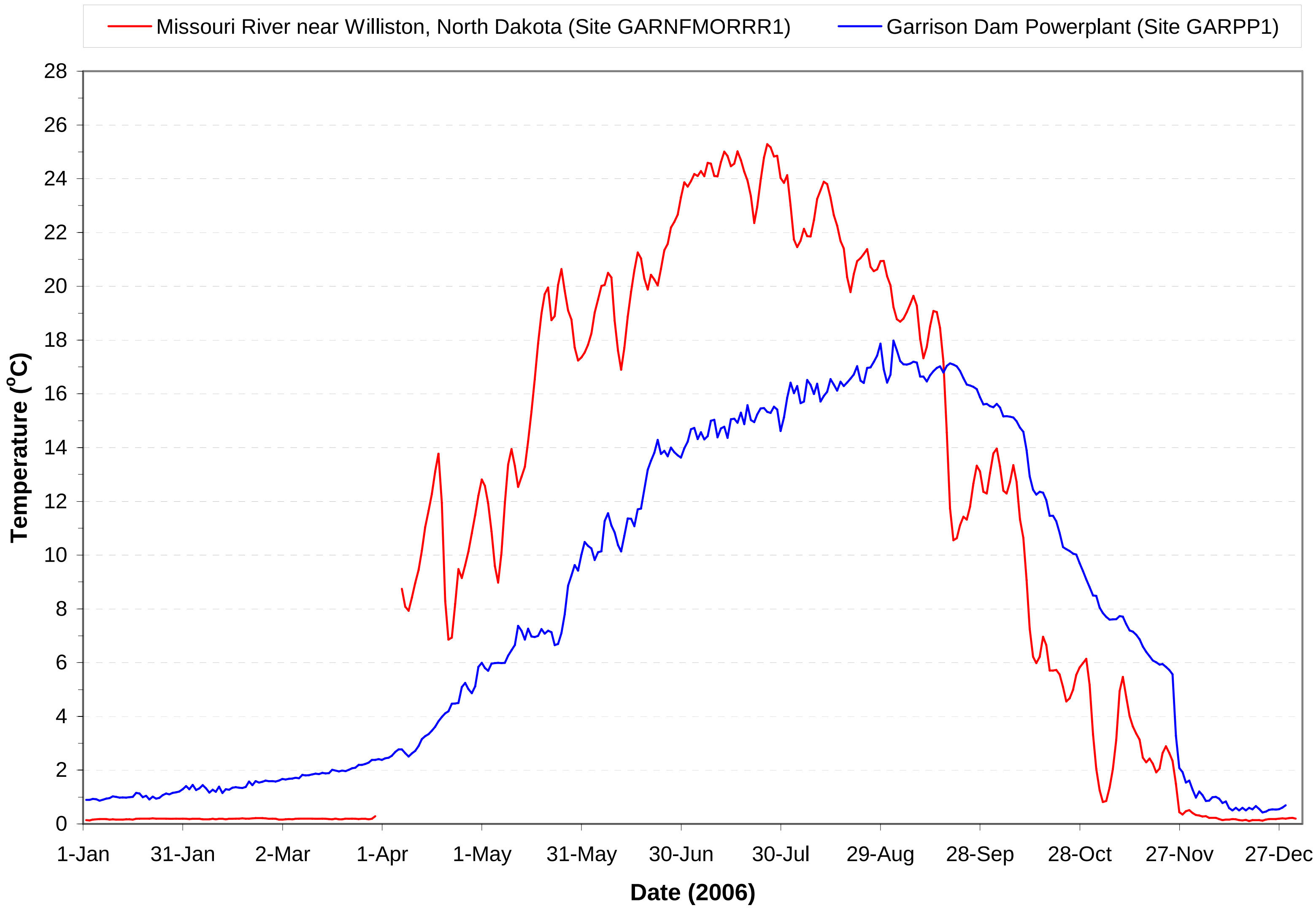


Plate 114. Mean daily water temperatures monitored at the Garrison Powerplant (i.e., site GARPP1) and the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) during 2006. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

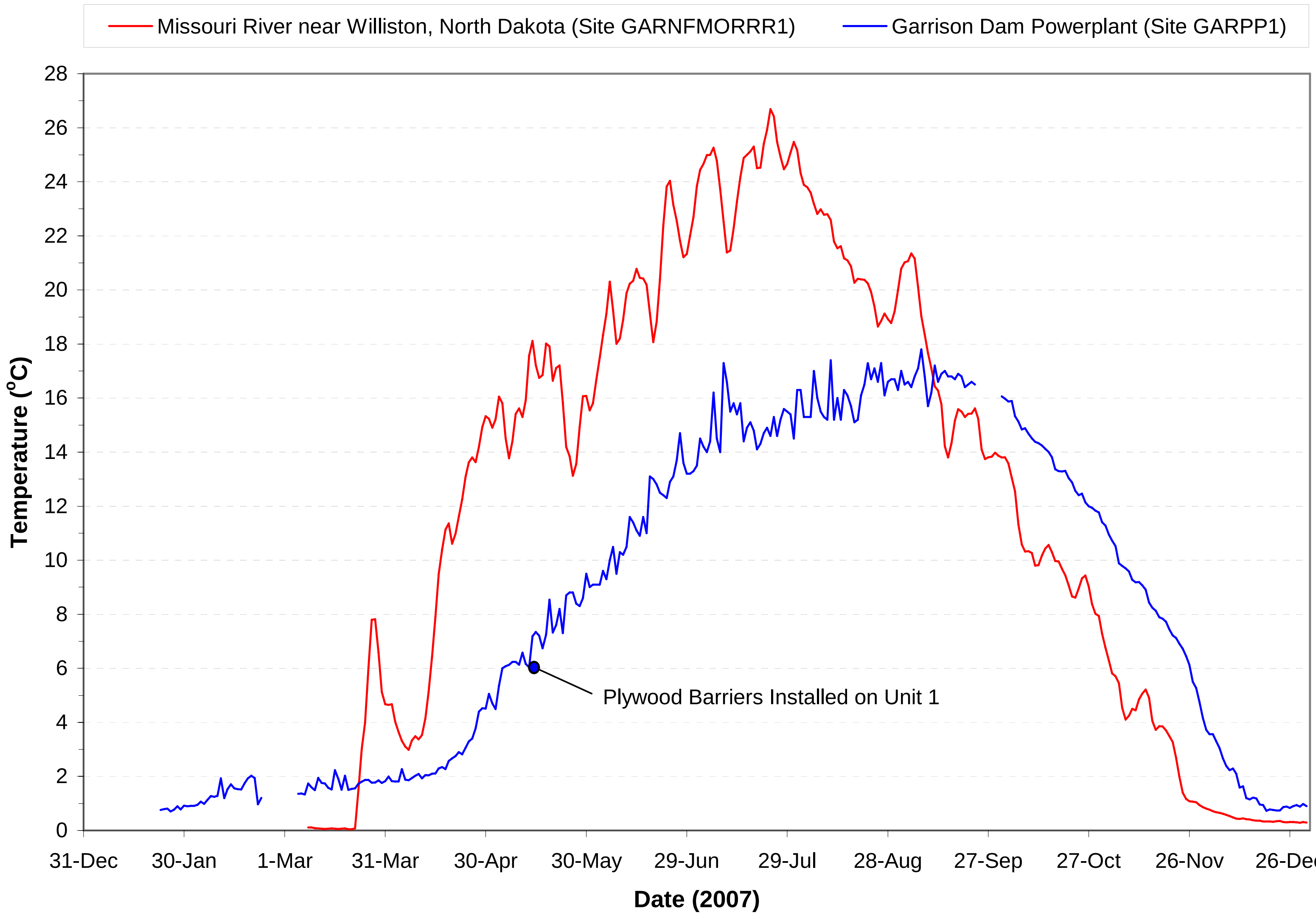


Plate 115. Mean daily water temperatures monitored at the Garrison Powerplant (i.e., site GARPP1) and the Missouri River near Williston, North Dakota (i.e., site GARNFMORRR1) during 2007. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

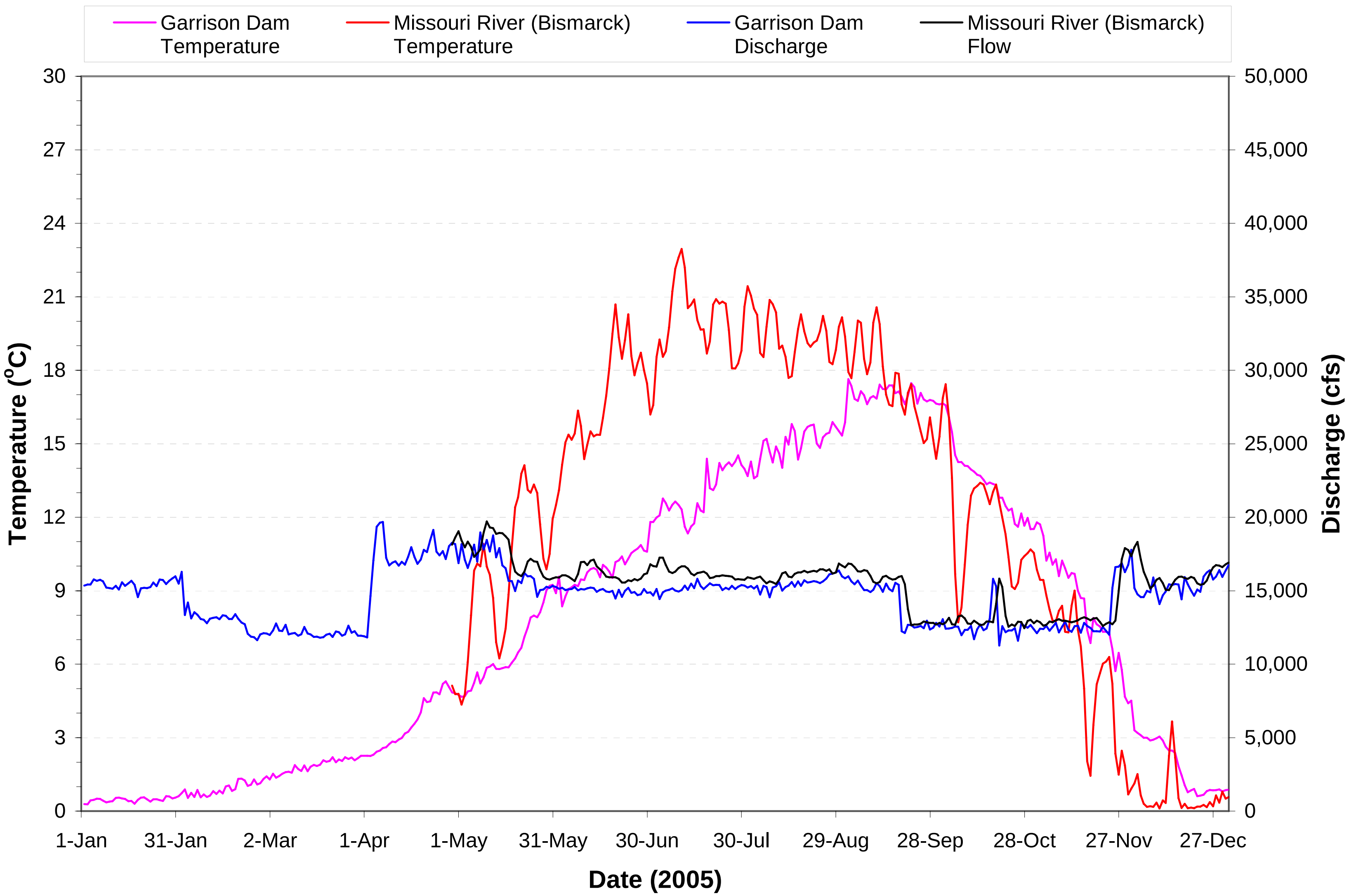


Plate 116. Mean daily water temperature and discharge for the Garrison Dam discharge and Missouri River at Bismarck, North Dakota for 2005. (Daily means based on hourly measurements.)

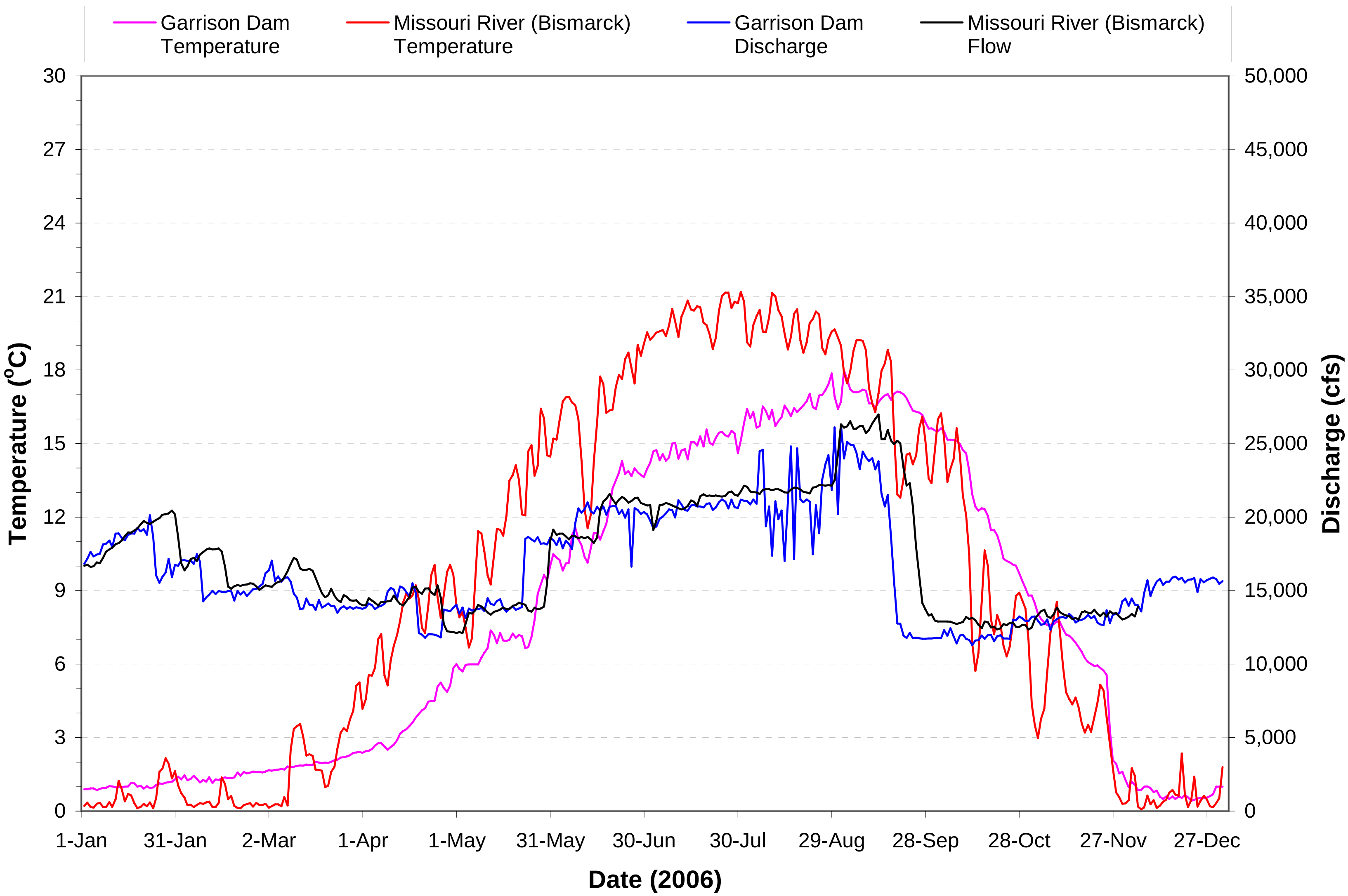


Plate 117. Mean daily water temperature and discharge for the Garrison Dam discharge and Missouri River at Bismarck, North Dakota for 2006. (Daily means based on hourly measurements.)

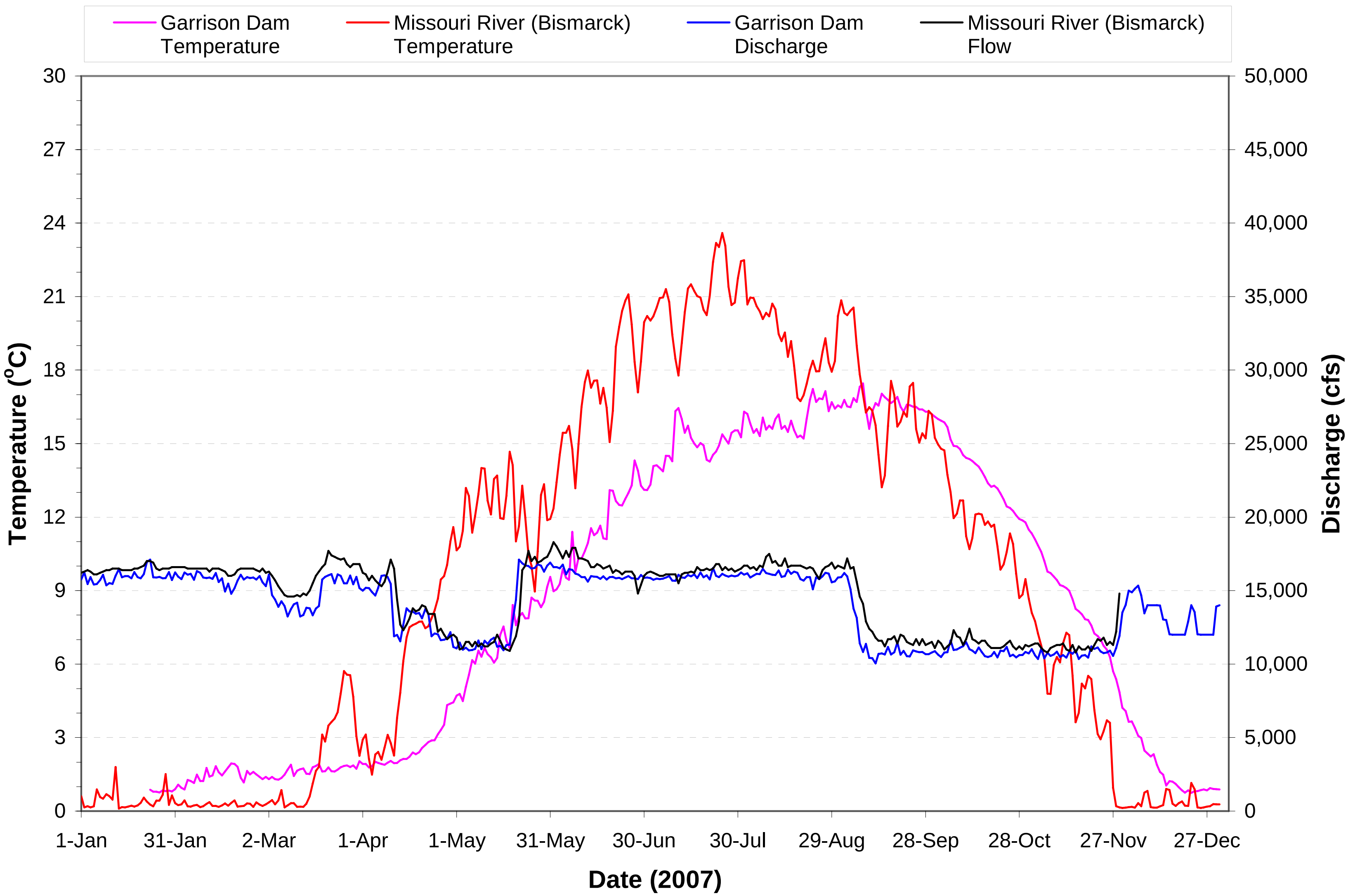


Plate 118. Mean daily water temperature and discharge for the Garrison Dam discharge and Missouri River at Bismarck, North Dakota for 2007. (Daily means based on hourly measurements.)

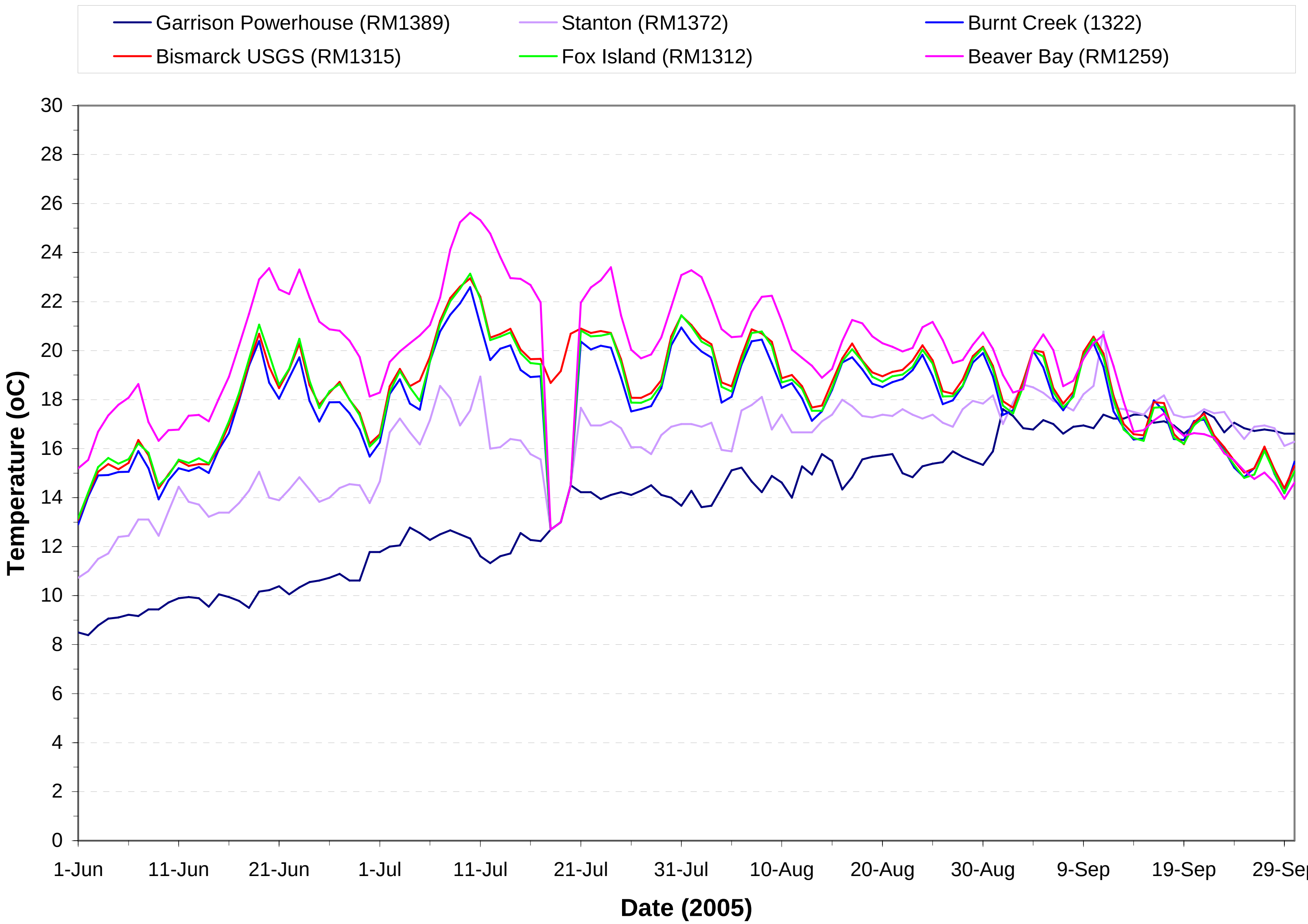


Plate 119. Mean daily water temperatures monitored in the Missouri River from Garrison Dam to Beaver Bay for the period June through September 2005.

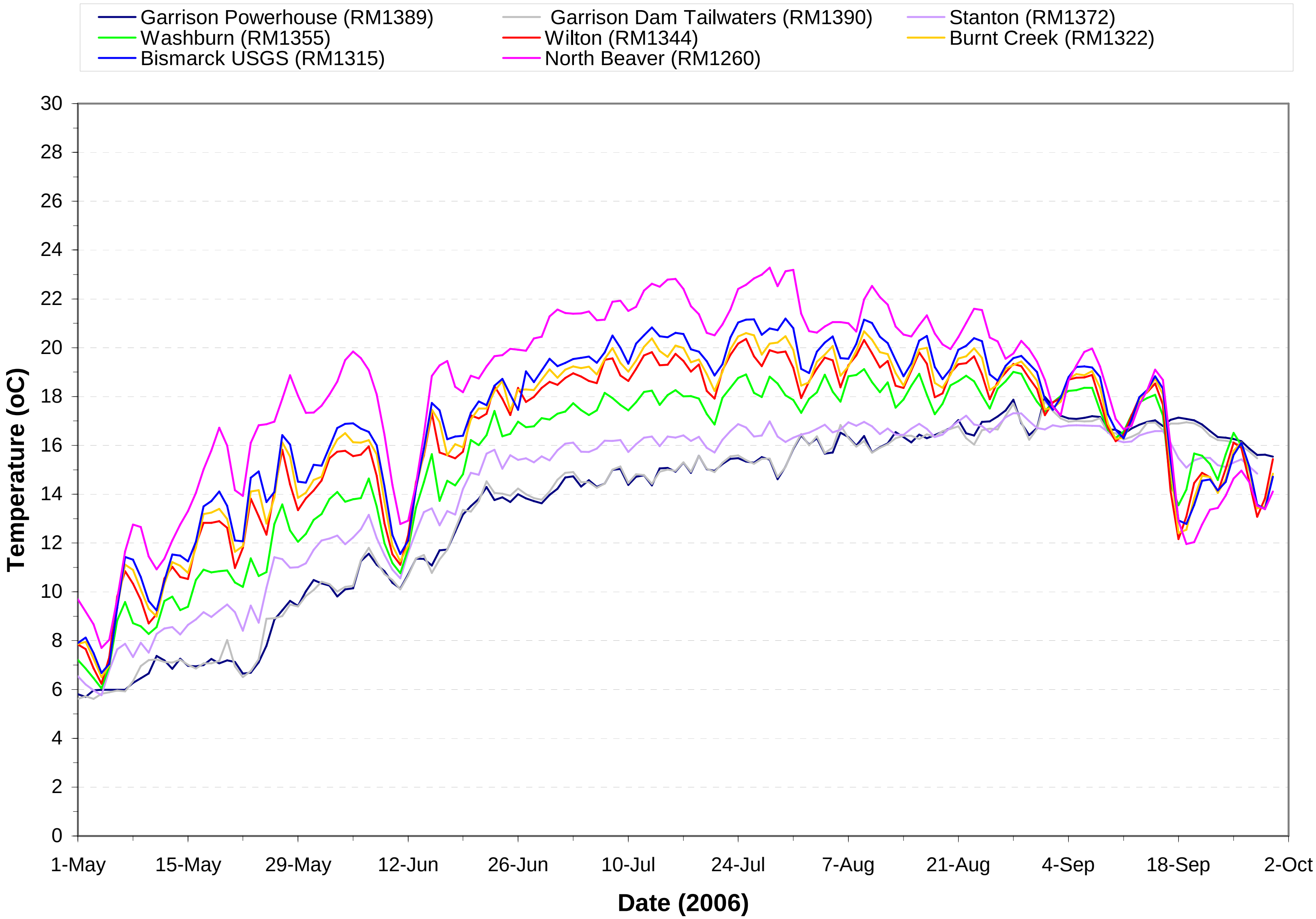


Plate 120. Mean daily water temperatures monitored in the Missouri River from Garrison Dam to Beaver Bay for the period May through September 2006.

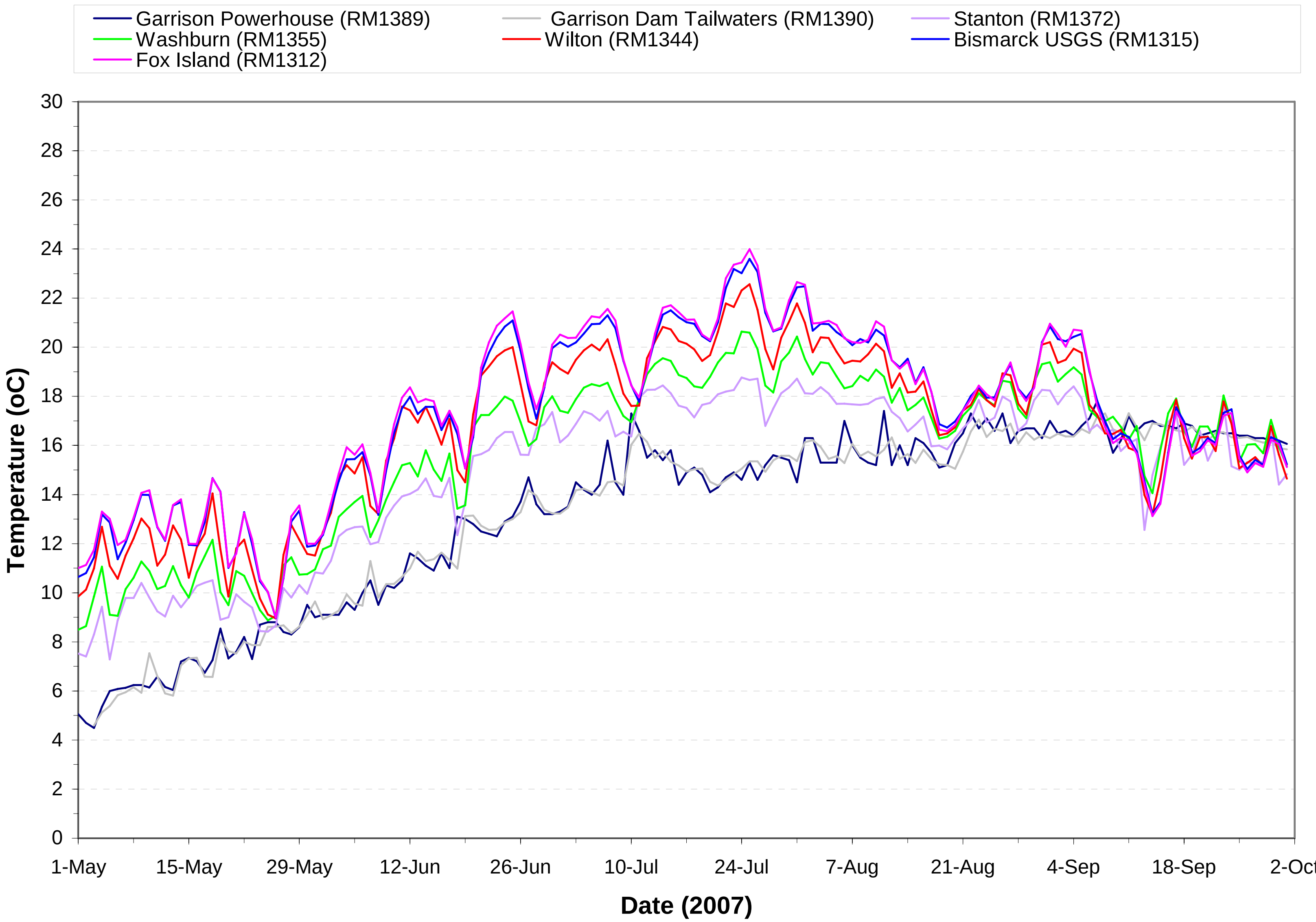


Plate 121. Mean daily water temperatures monitored in the Missouri River from Garrison Dam to Fox Island for the period May through September 2007.

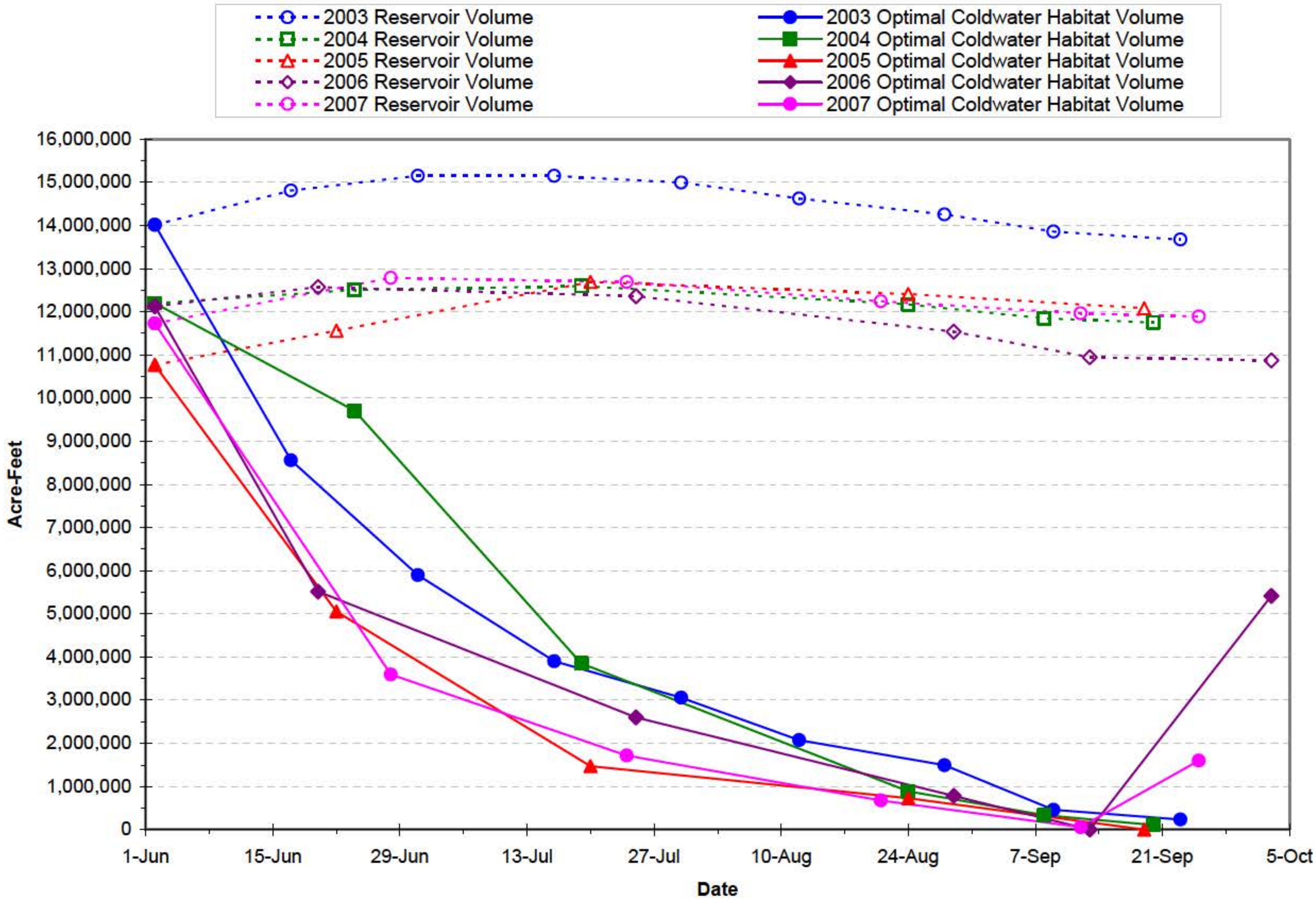


Plate 122. Estimated occurrence of optimal coldwater fishery habitat in Garrison Reservoir during the summer months of 2003, 2004, 2005, 2006, and 2007.

Plate 123. Summary of monthly (May through September) water quality conditions monitored in Oahe Reservoir near Oahe Dam (Site OAHLK1073A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	25	1578.8	1577.6	1570.9	1588.6	-----	-----	-----
Water Temperature (C)	0.1	1,083	13.3	11.8	6.1	24.9	18.3[1], 23 9[1]	212, 13	20%, 1%
Dissolved Oxygen (mg/l)	0.1	1,083	8.9	8.6	6.0	12.2	6.0[2], 7.0[2]	0, 66	0%, 6%
Dissolved Oxygen (% Sat.)	0.1	1,083	88.5	91.5	56.5	108.7	----	-----	-----
Specific Conductance (umho/cm)	1	1,082	674	694	534	765	-----	-----	-----
pH (S.U.)	0.1	997	8.2	8.2	7.4	9.0	6.6[3], 8.6[3]	0, 110	0%, 11%
Turbidity (NTUs)	0.1	1,040	6.1	2.8	n.d.	47.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	1,000	364	367	276	465	-----	-----	-----
Secchi Depth (in.)	1	25	150	144	70	252	-----	-----	-----
Alkalinity, Total (mg/l)	7	52	172	171	140	209	-----	-----	-----
Ammonia, Total (mg/l)	0.01	52	-----	0.05	n.d.	0.47	3.83 [4,5], 1.71 [4,6]	0	0%
Carbon, Total Organic (mg/l)	0.05	50	3.1	3.1	1.6	3.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	8	8	n.d.	20	-----	-----	-----
Chloride (mg/l)	1	22	9	9	9	11	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	866	-----	n.d.	n.d.	7	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	23	-----	1	n.d.	11	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	28	462	460	410	510	1,750[7]	0	0%
Iron, Total (ug/l)	40	21	100	100	n.d.	262	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	52	0.4	0.3	n.d.	0.7	-----	-----	-----
Manganese, Total (ug/l)	1	21	25	20	3	75	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	52	-----	n.d.	n.d.	0.19	10[7]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	30	-----	0.02	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	52	-----	0.03	n.d.	0.20	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	50	-----	n.d.	n.d.	0.05	-----	-----	-----
Sulfate (mg/l)	1	28	200	200	163	220	875[7]	0	0%
Suspended Solids, Total (mg/l)	4	52	-----	n.d.	n.d.	9	53[5], 30[6]	0	0%
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(5) Acute criterion for aquatic life.

(6) Chronic criterion for aquatic life.

(7) Daily maximum criterion for domestic water supply.

Plate 124. Summary of monthly (June through September) water quality conditions monitored in Oahe Reservoir near Cow Creek (site OAHLK1090DW) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1577.1	1576.8	1570.9	1583.2	-----	-----	-----
Water Temperature (C)	0.1	486	15.6	15.4	8.1	27.1	18.3[1], 23.9[1]	150, 15	31%, 3%
Dissolved Oxygen (mg/l)	0.1	486	8.1	8.1	6.1	10.3	6.0[2], 7.0[2]	0, 78	0%, 16%
Dissolved Oxygen (% Sat.)	0.1	486	84.9	86.8	59.2	102.8	-----	-----	-----
Specific Conductance (umho/cm)	1	486	676	694	536	770	-----	-----	-----
pH (S.U.)	0.1	486	8.3	8.4	7.5	8.9	6.6[3], 8.6[3]	0, 83	0%, 17%
Turbidity (NTUs)	0.1	484	5.8	2.1	n.d.	79.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	486	359	553	274	468	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	486	-----	1	n.d.	39	-----	-----	-----
Secchi Depth (in)	1	12	139	137	60	228	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

Plate 125. Summary of monthly (May through September) water quality conditions monitored in Oahe Reservoir near the confluence of the Cheyenne River (Site OAHLK1110DW) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1577.1	1576.9	1570.9	1583.2	-----	-----	-----
Water Temperature (C)	0.1	373	17.9	17.8	9.7	25.2	18.3[1], 23.9[1]	175, 28	47%, 8%
Dissolved Oxygen (mg/l)	0.1	373	7.7	8.0	3.4	9.3	6.0[2], 7.0[2]	37, 70	10%, 19%
Dissolved Oxygen (% Sat.)	0.1	373	85.5	89.9	33.9	104.7	----	-----	-----
Specific Conductance (umho/cm)	1	373	669	682	536	782	-----	-----	-----
pH (S.U.)	0.1	373	8.3	8.4	7.5	8.8	6.6[3], 8.6[3]	0, 76	0%, 20%
Turbidity (NTUs)	0.1	368	5.7	3.0	0.1	37.3	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	373	355	334	245	459	-----	-----	-----
Secchi Depth (in.)	1	12	115	114	60	192	-----	-----	-----
Alkalinity, Total (mg/l)	7	27	165	165	140	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	27	-----	n.d.	n.d.	0.12	2.59 [4,5], 0.98 [4,6]	0	0%
Carbon, Total Organic (mg/l)	0.05	25	3.1	3.1	1.3	4.6	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	16	12	11	2	19	-----	-----	-----
Chloride (mg/l)	1	16	10	10	8	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	370	-----	1	n.d.	6	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	12	-----	n.d.	n.d.	3	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	26	459	453	414	556	1,750[7]	0	0%
Iron, Total (ug/l)	40	20	158	150	n.d.	394	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	27	0.3	0.3	n.d.	0.7	-----	-----	-----
Manganese, Total (ug/l)	1	20	36	23	n.d.	129	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	26	-----	n.d.	n.d.	0.20	10[7]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	27	-----	0.01	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	27	0.06	0.04	n.d.	0 25	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	27	-----	n.d.	n.d.	0.04	-----	-----	-----
Sulfate (mg/l)	1	25	194	200	161	220	875[7]	0	0%
Suspended Solids, Total (mg/l)	4	26	-----	n.d.	n.d.	13	53[5], 30[6]	0	0%
Microcystins, Total (ug/l)	0.2	12	-----	n.d.	n.d.	0.23	-----	-----	-----

n.d. = Not detected.
* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).
*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.
(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.
(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.
(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(5) Acute criterion for aquatic life.
(6) Chronic criterion for aquatic life.
(7) Daily maximum criterion for domestic water supply.

Plate 126. Summary of monthly (June through September) water quality conditions monitored in Oahe Reservoir near Sutton Bay (site OAHLK1135DW) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	11	1577.1	1576.9	1570.9	1583.2	-----	-----	-----
Water Temperature (C)	0.1	317	18.7	18.6	10.5	25.4	18.3[1], 23.9[1]	163, 13	51%, 4%
Dissolved Oxygen (mg/l)	0.1	317	7.4	7.8	3.5	9.7	6.0[2], 7.0[2]	50, 82	16%, 26%
Dissolved Oxygen (% Sat.)	0.1	316	83.1	88.5	35.9	107.3	-----	-----	-----
Specific Conductance (umho/cm)	1	317	654	659	532	732	-----	-----	-----
pH (S.U.)	0.1	317	8.3	8.3	7.6	8.6	6.6[3], 8.6[3]	0	0%
Turbidity (NTUs)	0.1	315	6.2	3.7	0.6	34.1	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	316	378	376	296	469	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	313	-----	1	n.d.	6	-----	-----	-----
Secchi Depth (in)	1	11	90	100	40	122	-----	-----	-----

* Results are a combination of all sampling depths.
** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).
*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.
(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.
(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

Plate 127. Summary of monthly (June through September) water quality conditions monitored in Oahe Reservoir near Whitlocks Bay (Site OAHLK1153DW) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1577.1	1576.9	1571.1	1583.2	-----	-----	-----
Water Temperature (C)	0.1	291	19.6	20.2	11.5	25.7	18.3(1), 23 9(1)	183, 23	63%, 8%
Dissolved Oxygen (mg/l)	0.1	291	7.3	7.7	2.5	9.3	6.0(2), 7.0(2)	42, 65	14%, 22%
Dissolved Oxygen (% Sat.)	0.1	291	83.1	88.7	27.7	104.8	----	-----	-----
Specific Conductance (umho/cm)	1	290	645	656	539	741	-----	-----	-----
pH (S.U.)	0.1	291	8.3	8.4	7.5	8.6	6.6(3), 8.6(3)	0	0%
Turbidity (NTUs)	0.1	290	5.7	4.6	1.1	23.0	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	291	391	395	297	492	-----	-----	-----
Secchi Depth (in.)	1	12	78	79	41	120	-----	-----	-----
Alkalinity, Total (mg/l)	7	26	164	168	140	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	26	-----	0.03	n.d.	0.31	2.59 (4,5), 0.85 (4,6)	0	0%
Carbon, Total Organic (mg/l)	0.05	24	3.2	3.2	1.6	5.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	16	12	11	n.d.	23	-----	-----	-----
Chloride (mg/l)	1	16	9	9	8	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	289	-----	1	n.d.	26	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	12	4	4	n.d.	7	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	26	450	439	420	532	1,750(7)	0	0%
Iron, Total (ug/l)	40	20	218	198	40	589	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	26	0.4	0.4	0.2	0.8	-----	-----	-----
Manganese, Total (ug/l)	1	20	120	67	10	532	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	26	-----	0.04	n.d.	0.30	10(7)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	26	-----	0.03	n.d.	0.16	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	26	0.07	0.06	n.d.	0 23	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	26	-----	n.d.	n.d.	0.04	-----	-----	-----
Sulfate (mg/l)	1	24	181	190	152	200	875(7)	0	0%
Suspended Solids, Total (mg/l)	4	26	-----	n.d.	n.d.	14	53(5), 30(6)	0	0%
Microcystins, Total (ug/l)	0.2	12	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(5) Acute criterion for aquatic life.

(6) Chronic criterion for aquatic life.

(7) Daily maximum criterion for domestic water supply.

Plate 128. Summary of monthly (June through September) water quality conditions monitored in Oahe Reservoir near Swan Creek (site OAHLK1176DW) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1577.1	1576.9	1571.1	1583.2	-----	-----	-----
Water Temperature (C)	0.1	213	20.9	20.4	15.5	25.3	18.3(1), 23.9(1)	169, 40	79%, 19%
Dissolved Oxygen (mg/l)	0.1	213	7.6	7.8	2.7	9.7	6.0(2), 7.0(2)	15, 34	7%, 16%
Dissolved Oxygen (% Sat.)	0.1	213	88.7	90.2	31.4	110.7	-----	-----	-----
Specific Conductance (umho/cm)	1	213	649	659	529	763	-----	-----	-----
pH (S.U.)	0.1	213	8.4	8.4	7.8	8.7	6.6(3), 8.6(3)	0, 14	0%, 7%
Turbidity (NTUs)	0.1	211	6.2	4.7	1.5	26.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	213	402	411	294	477	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	212	2	2	n.d.	11	-----	-----	-----
Secchi Depth (in)	1	12	59	55	37	92	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

Plate 129. Summary of monthly (June through September) water quality conditions monitored in Oahe Reservoir near Mobridge, South Dakota (Site OAHLK1196DW – L7) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	12	1577.1	1576.9	1571.1	1583 2	-----	-----	-----
Water Temperature (C)	0.1	156	21 3	22.2	15.3	25.1	18.3[1], 23.9[1]	145, 45	93%, 29%
Dissolved Oxygen (mg/l)	0.1	156	7.6	7.8	5.1	8.6	6.0[2], 7.0[2]	5, 23	3%, 15%
Dissolved Oxygen (% Sat.)	0.1	156	89.7	90.1	63.7	98 1	----	-----	-----
Specific Conductance (umho/cm)	1	156	645	651	530	749	-----	-----	-----
pH (S.U.)	0.1	156	8.4	8.4	8.2	8.7	6.6[3], 8.6[3]	0, 20	0%, 13%
Turbidity (NTUs)	0.1	154	13.6	13.1	4.2	31.6	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	156	410	411	296	516	-----	-----	-----
Secchi Depth (in.)	1	12	32	26	17	65	-----	-----	-----
Alkalinity, Total (mg/l)	7	24	161	165	98	180	-----	-----	-----
Ammonia, Total (mg/l)	0.01	24	-----	0.04	n.d.	0.33	2.59 [4,5], 0.75 [4,6]	0	0%
Carbon, Total Organic (mg/l)	0.05	21	3 3	3.2	2.6	4.4	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	16	13	12	9	22	-----	-----	-----
Chloride (mg/l)	1	16	9	9	8	10	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	155	5	3	1	17	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	11	6	5	1	15	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	24	457	449	410	560	1,750[7]	0	0%
Iron, Total (ug/l)	40	20	344	330	100	699	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	24	0.4	0.4	n.d.	0.8	-----	-----	-----
Manganese, Total (ug/l)	1	20	49	47	20	110	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	24	-----	n.d.	n.d.	0.11	10[7]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	24	-----	0.02	n.d.	0.09	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	24	0.05	0.05	n.d.	0.15	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	24	-----	n.d.	n.d.	0.04	-----	-----	-----
Sulfate (mg/l)	1	22	176	190	142	200	875[7]	0	0%
Suspended Solids, Total (mg/l)	4	24	-----	10	n.d.	18	53[5], 30[6]	0	0%
Microcystins, Total (ug/l)	0.2	12	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Oahe Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23.9 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria.

(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(5) Acute criterion for aquatic life.

(6) Chronic criterion for aquatic life.

(7) Daily maximum criterion for domestic water supply.

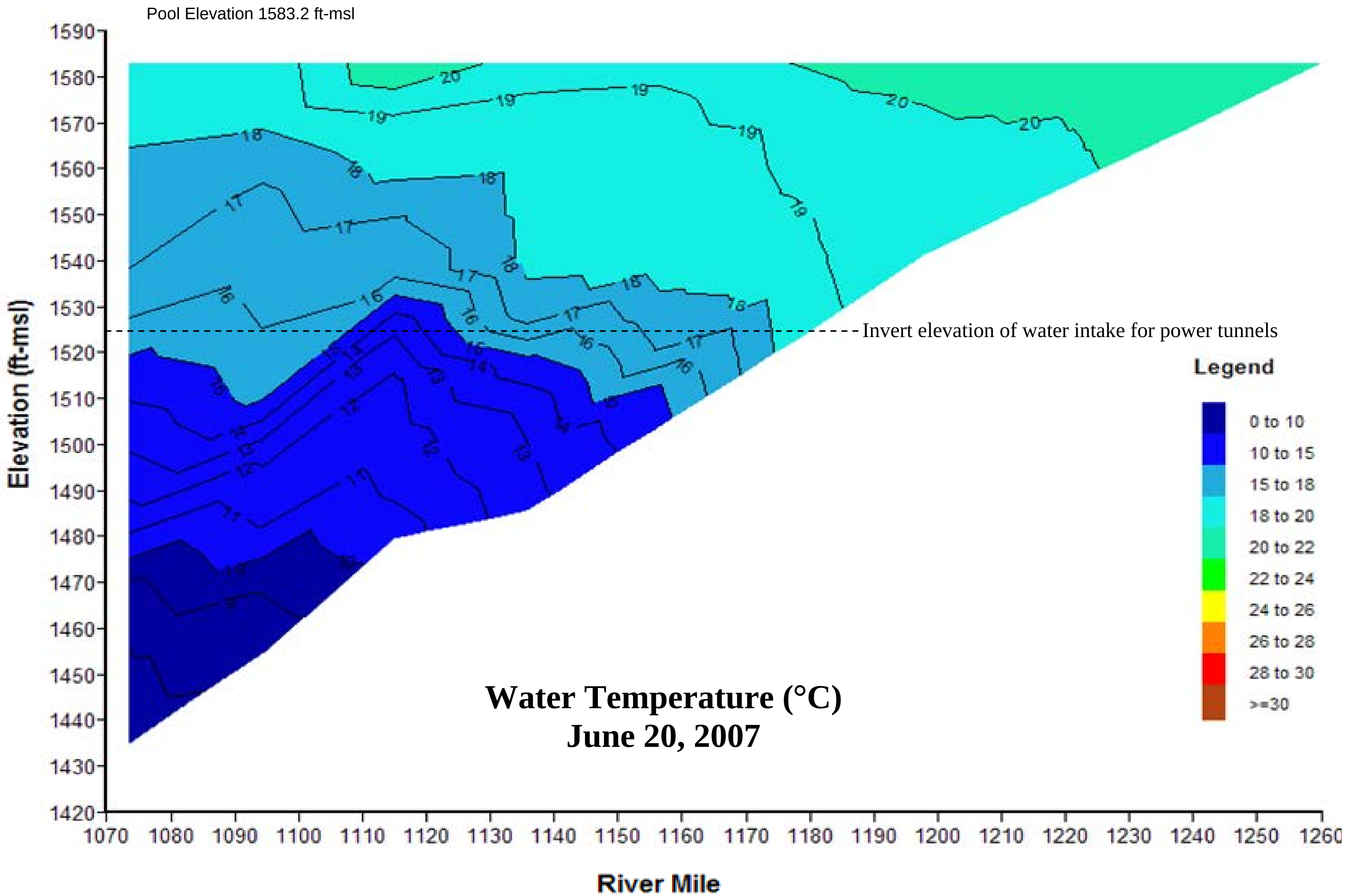


Plate 130. Longitudinal water temperature (°C) contour plot of Oahe Reservoir based on depth-profile water temperatures measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on June 20, 2007.

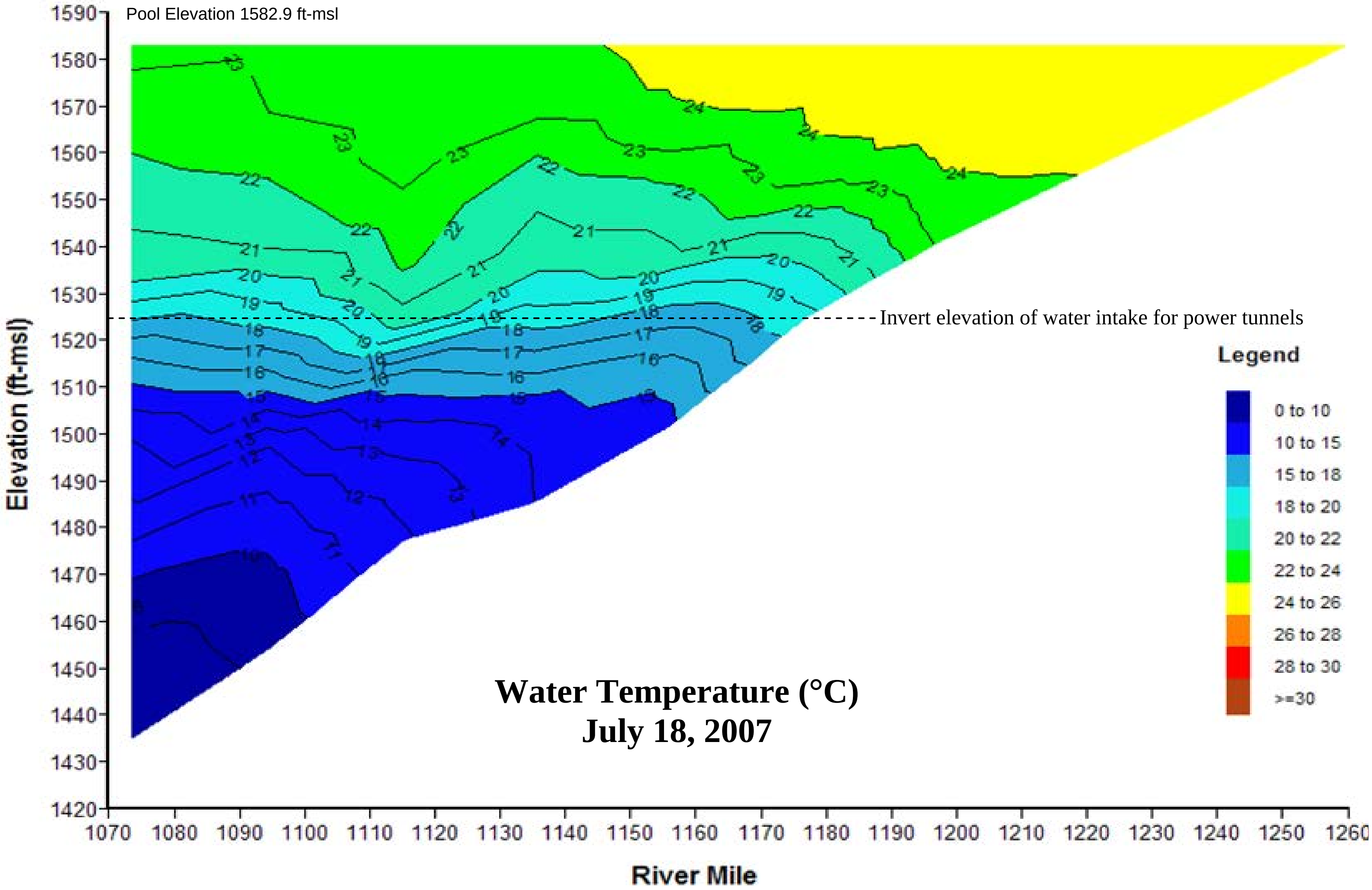


Plate 131. Longitudinal water temperature (°C) contour plot of Oahe Reservoir based on depth-profile water temperatures measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on July 18, 2007.

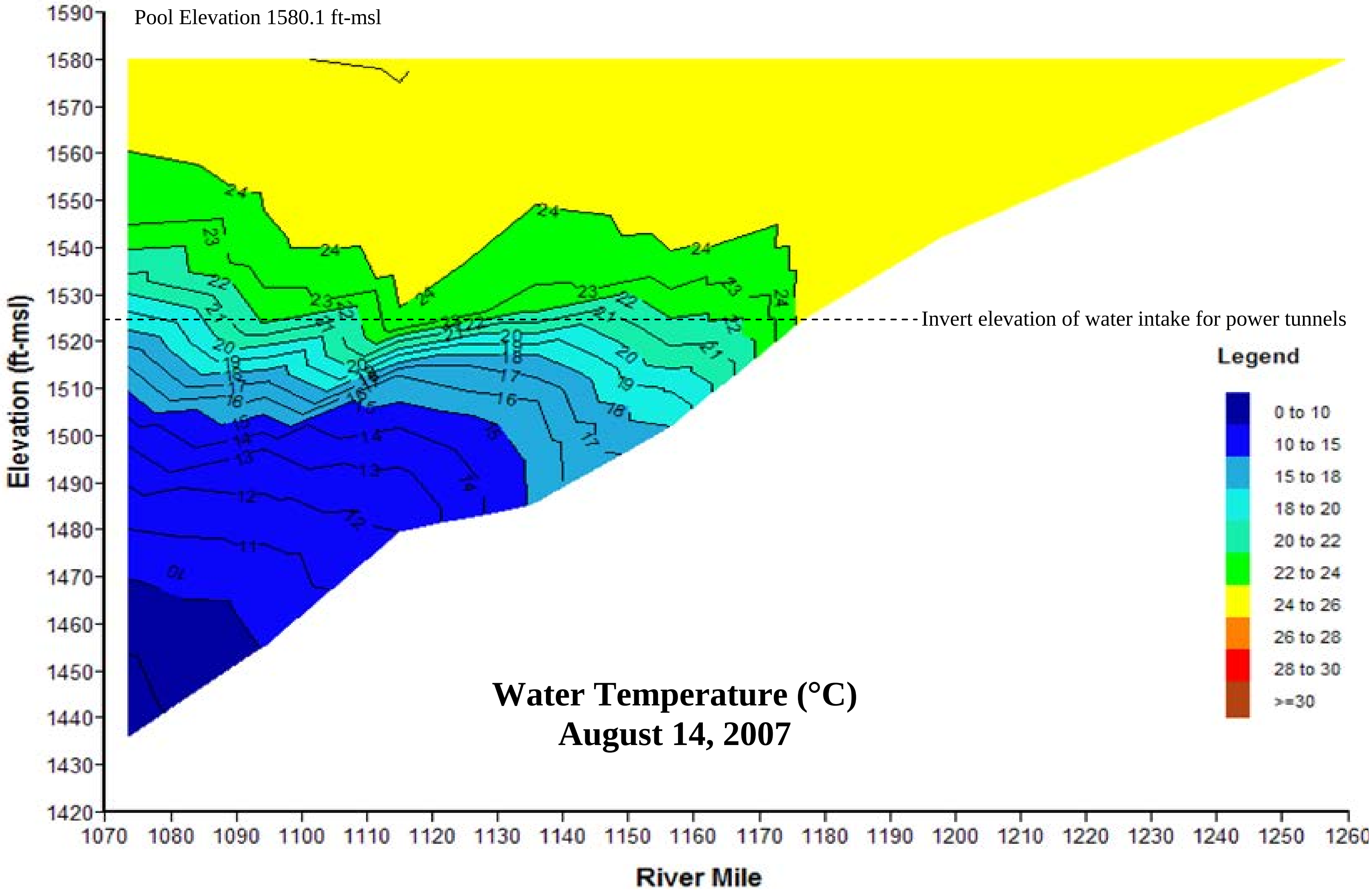


Plate 132. Longitudinal water temperature (°C) contour plot of Oahe Reservoir based on depth-profile water temperatures measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on August 14, 2007.

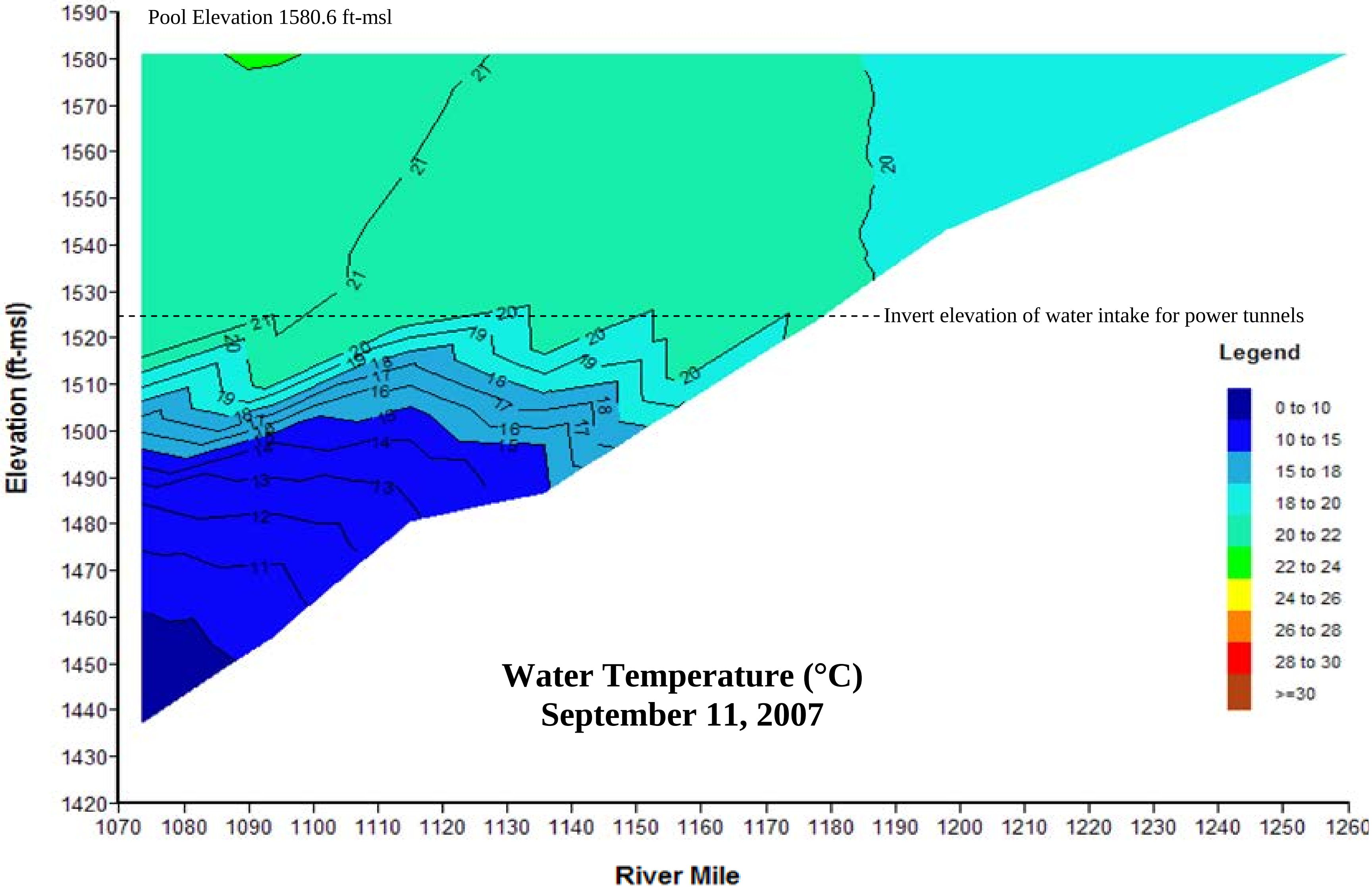


Plate 133. Longitudinal water temperature (°C) contour plot of Oahe Reservoir based on depth-profile water temperatures measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on September 11, 2007.

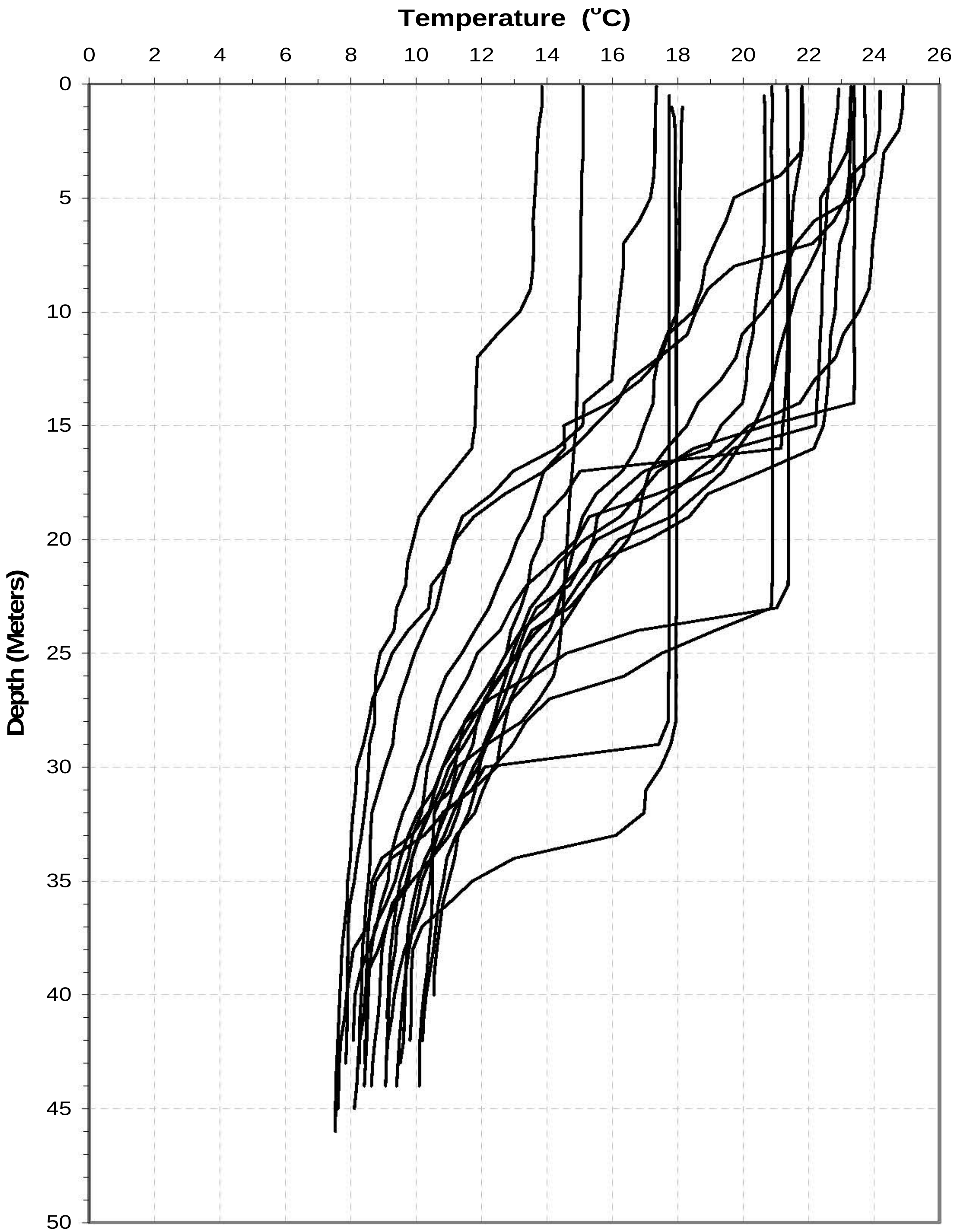


Plate 134. Temperature depth profiles for Oahe Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., OAHLK1073A) during the summer months over the 5-year period of 2003 to 2007**.**

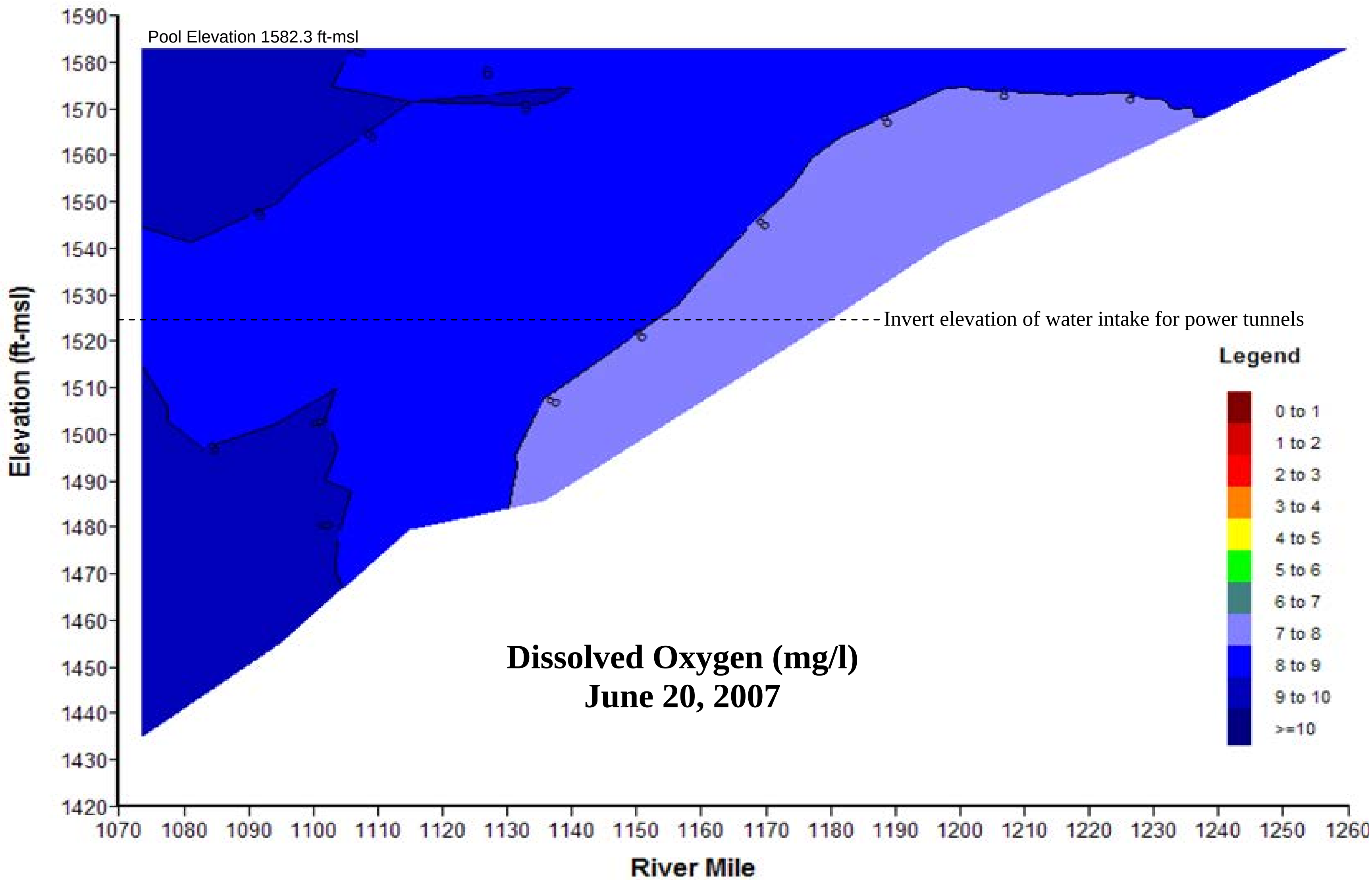


Plate 135. Longitudinal dissolved oxygen (mg/l) contour plot of Oahe Reservoir based on depth-profile dissolved oxygen concentrations measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on June 20, 2007.

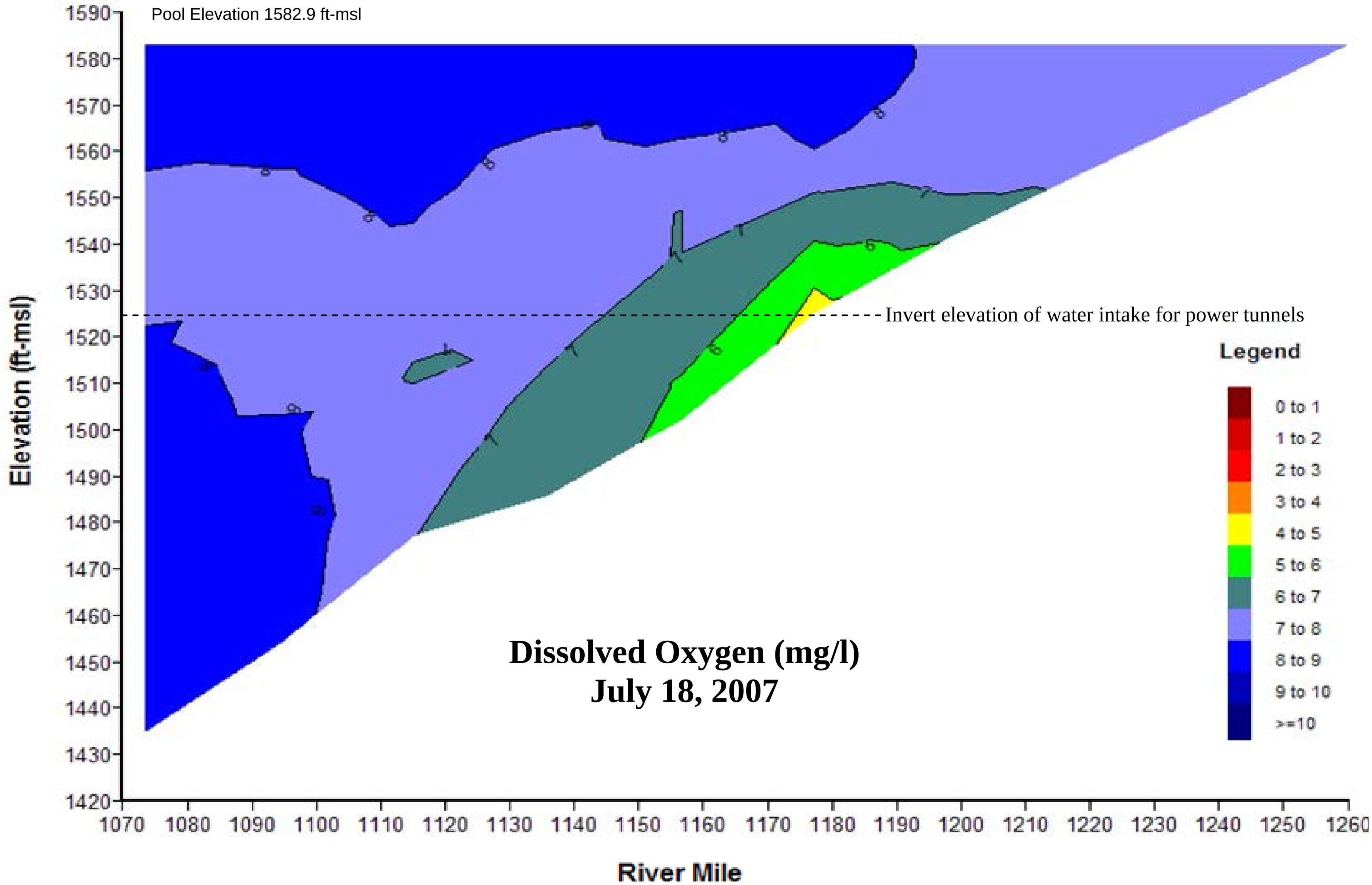


Plate 136. Longitudinal dissolved oxygen (mg/l) contour plot of Oahe Reservoir based on depth-profile dissolved oxygen concentrations measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on July 18, 2007.

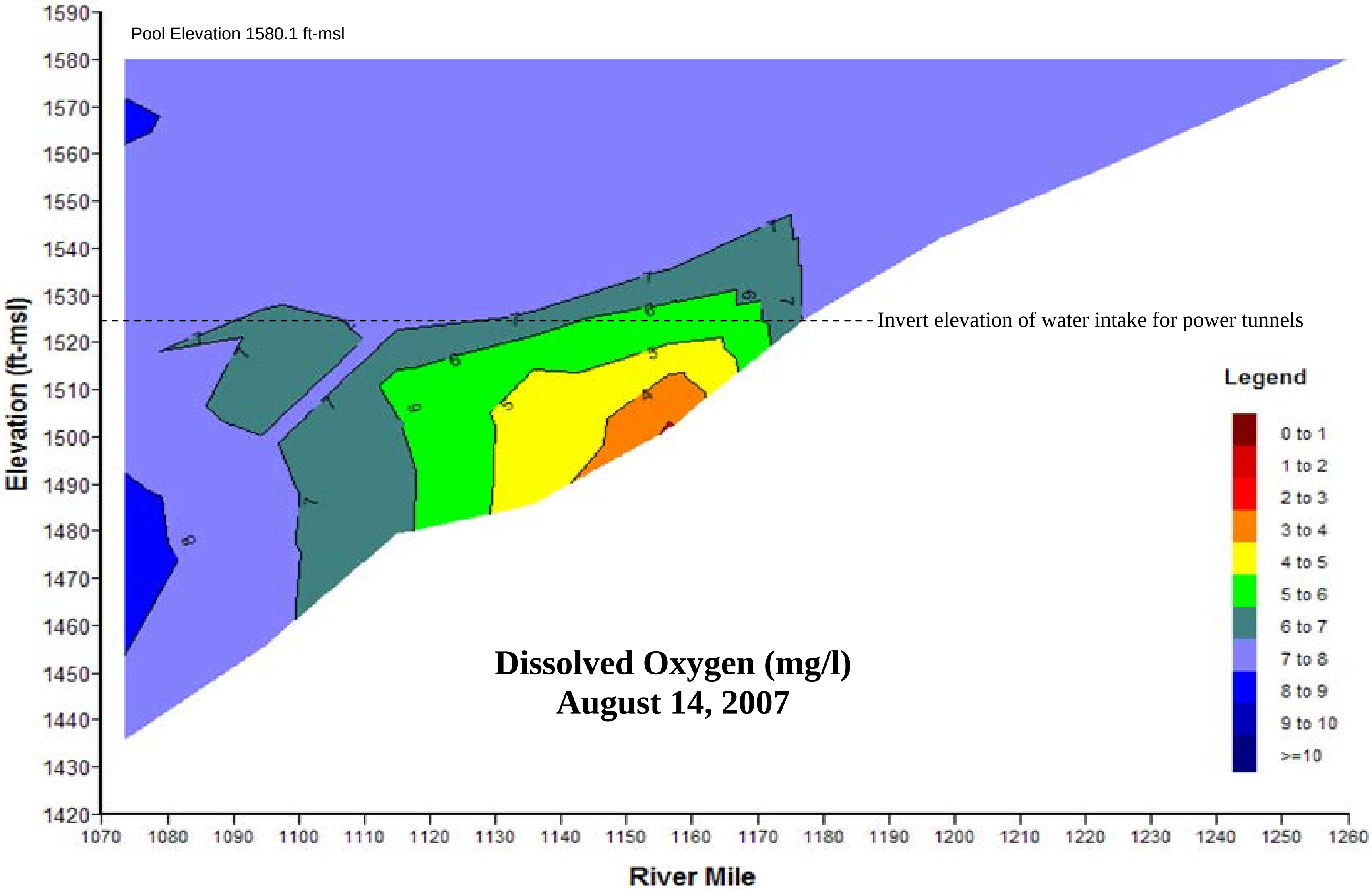


Plate 137. Longitudinal dissolved oxygen (mg/l) contour plot of Oahe Reservoir based on depth-profile dissolved oxygen concentrations measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on August 14, 2007.

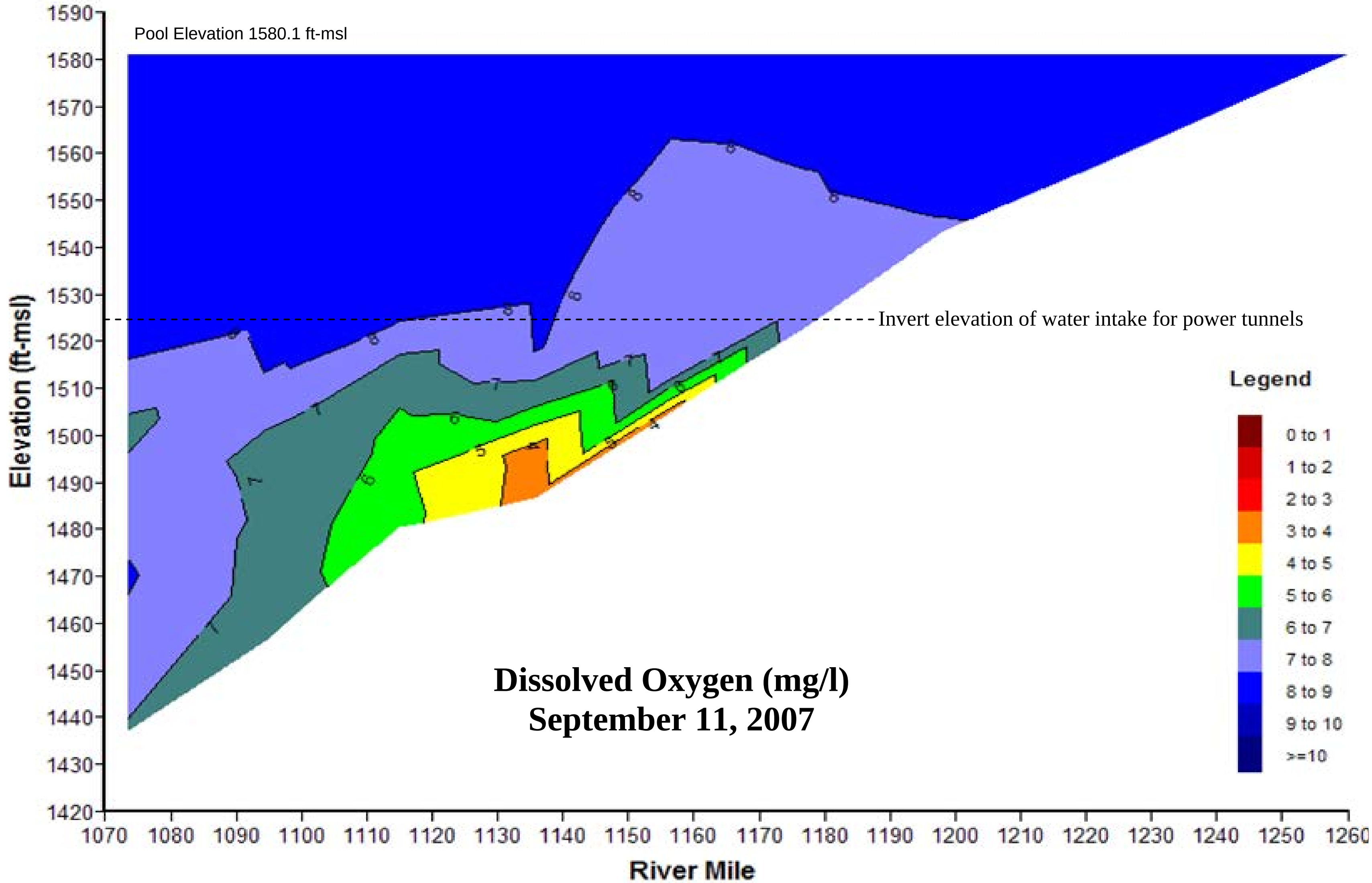


Plate 138. Longitudinal dissolved oxygen (mg/l) contour plot of Oahe Reservoir based on depth-profile dissolved oxygen concentrations measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on September 11, 2007.

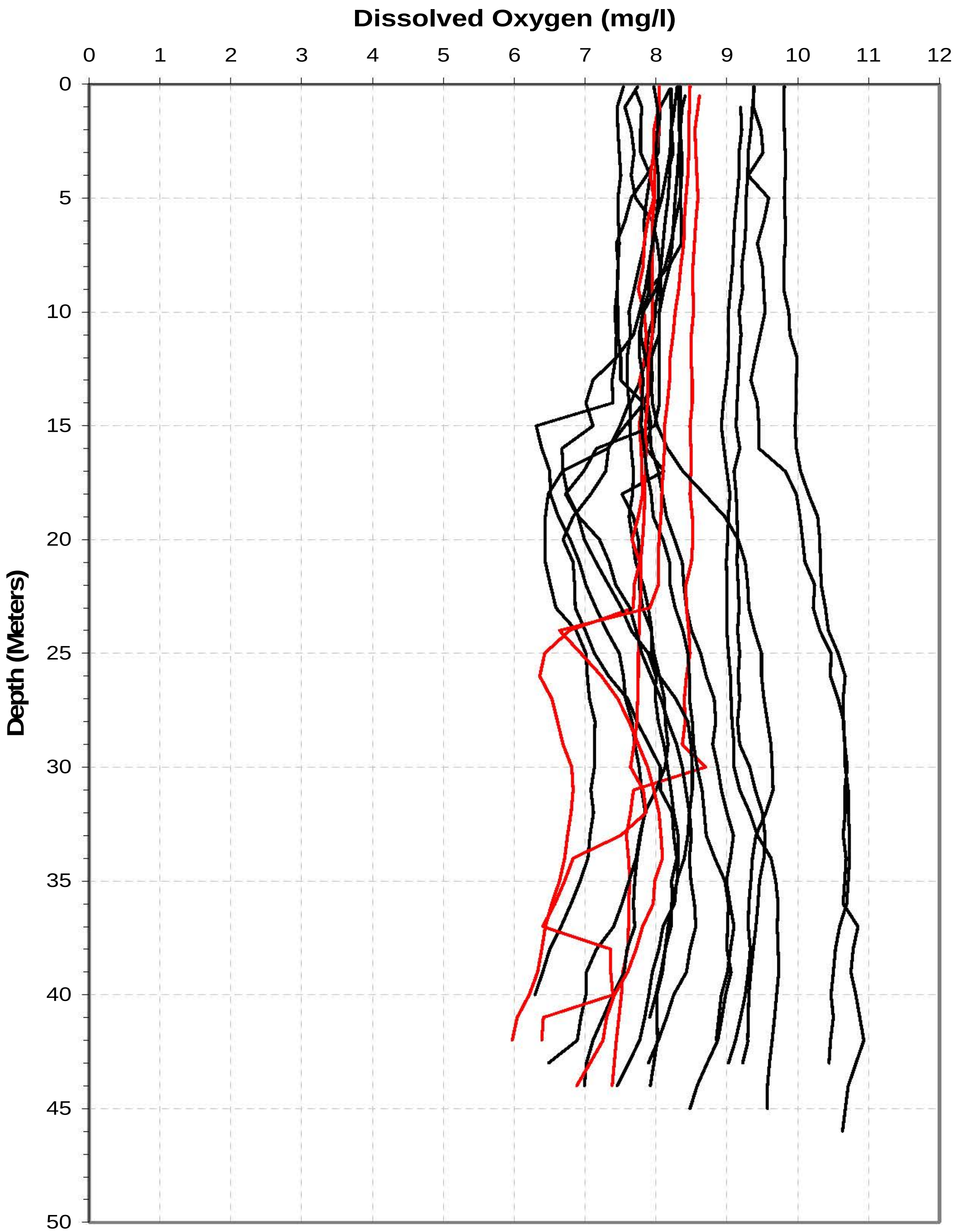


Plate 139. Dissolved oxygen depth profiles for Oahe Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., OAHLK1073A) during the summer months of the 5-year period of 2003 to 2007. (Note: Red profile plots were measured in the month of September.)

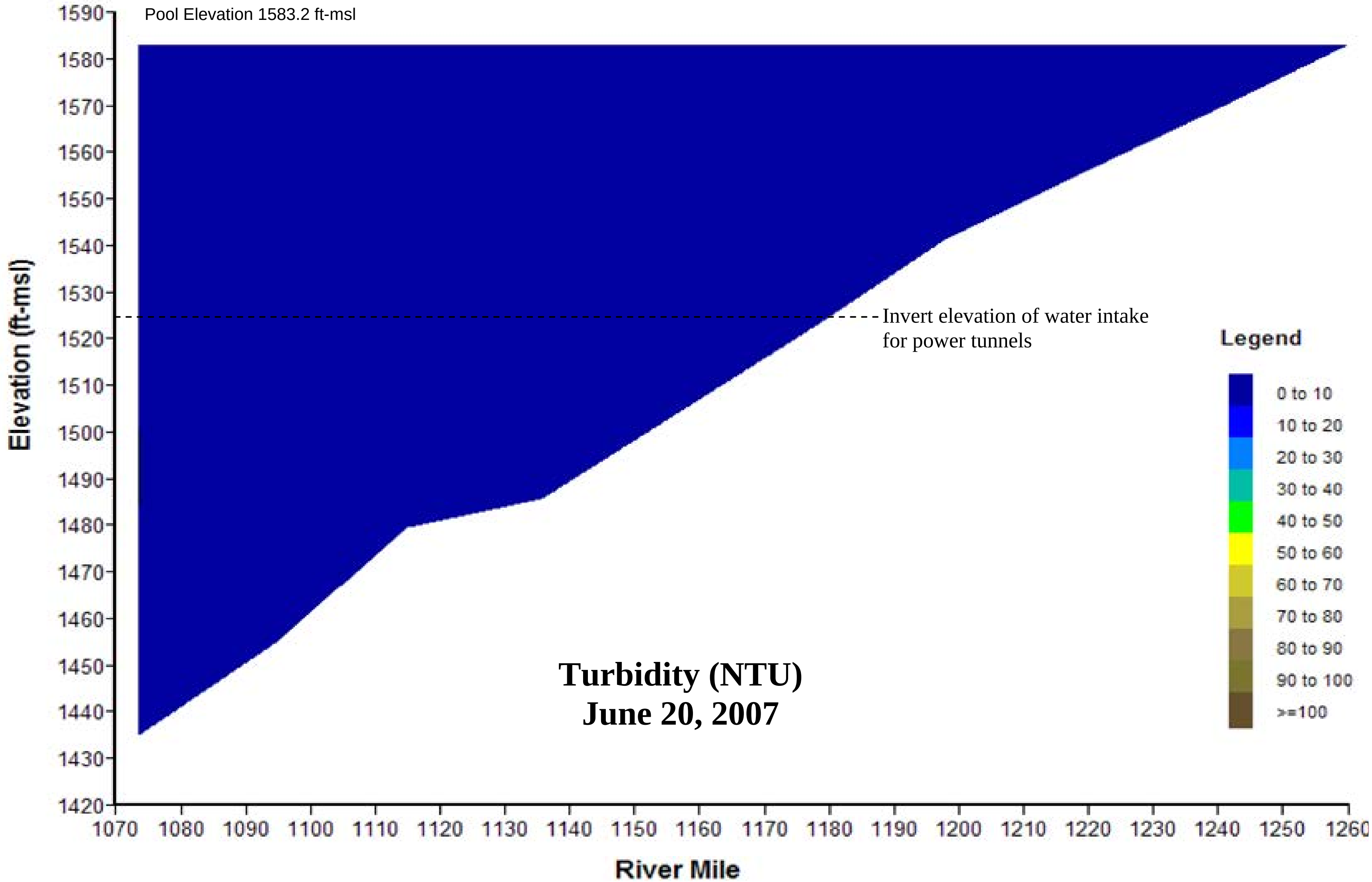


Plate 140. Longitudinal turbidity (NTU) contour plot of Oahe Reservoir based on depth-profile turbidity levels measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on June 20, 2007.

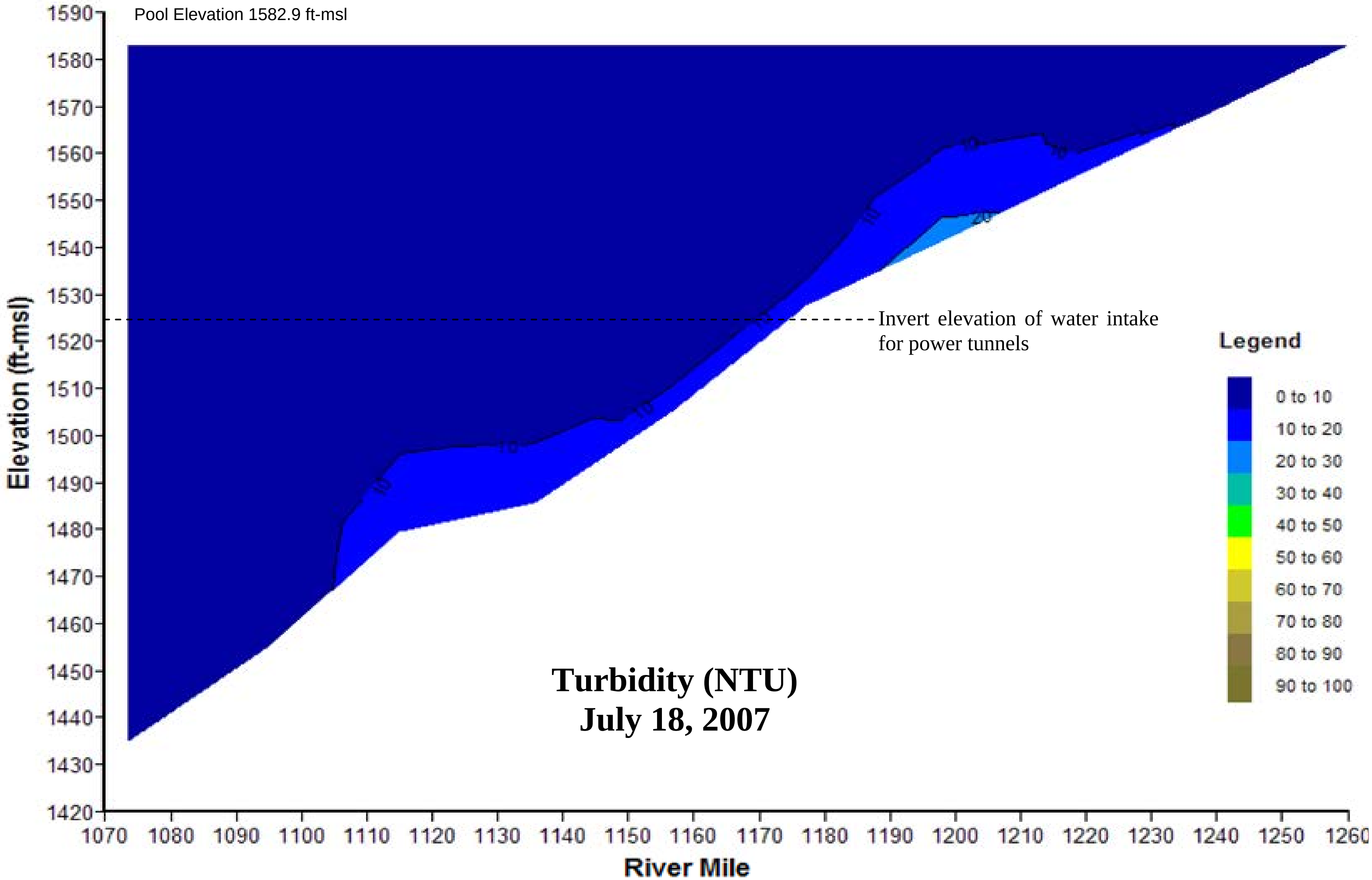


Plate 141. Longitudinal turbidity (NTU) contour plot of Oahe Reservoir based on depth-profile turbidity levels measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on July 18, 2007.

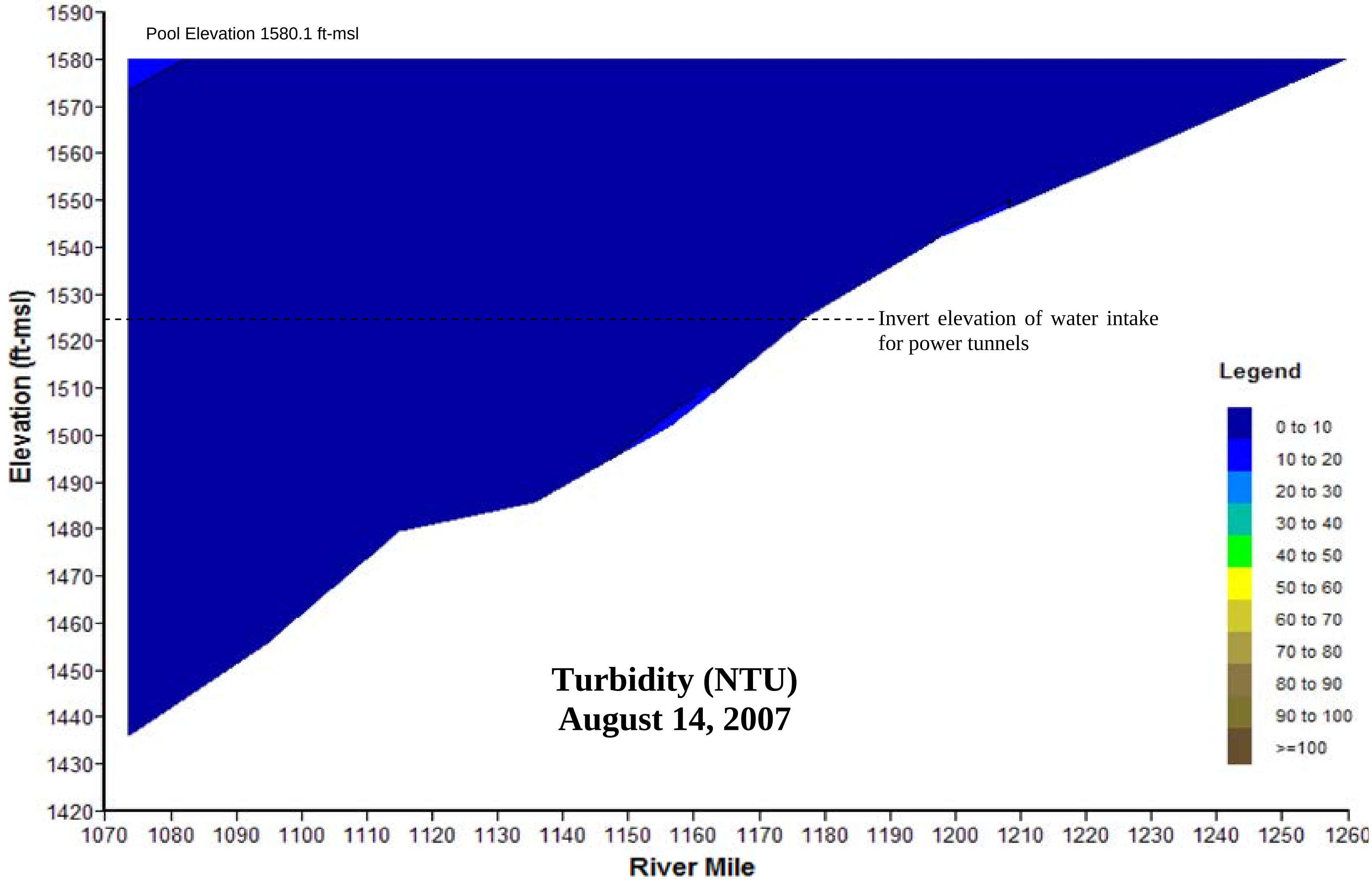


Plate 142. Longitudinal turbidity (NTU) contour plot of Oahe Reservoir based on depth-profile turbidity levels measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on August 14, 2007.

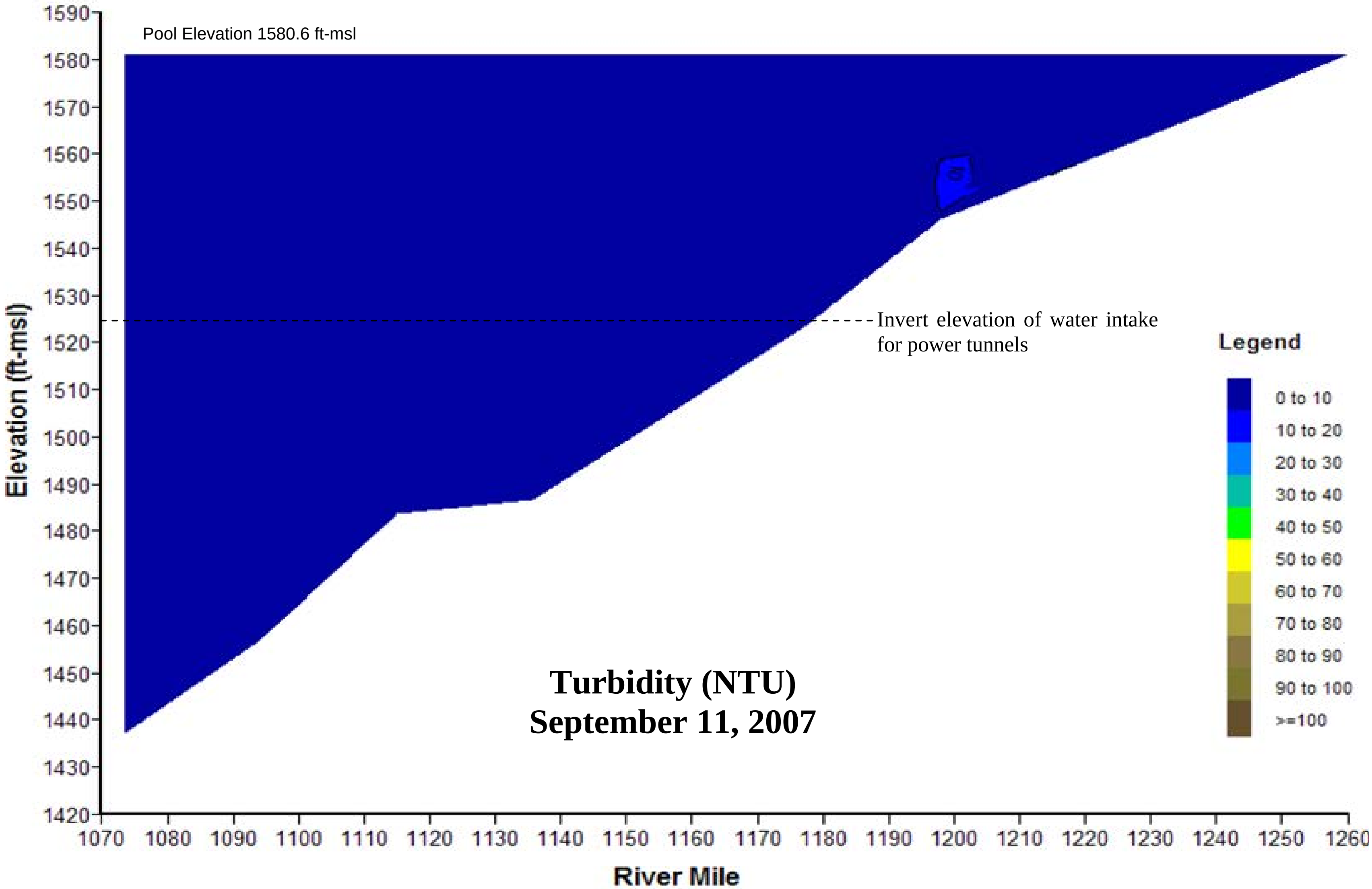


Plate 143. Longitudinal turbidity (NTU) contour plot of Oahe Reservoir based on depth-profile turbidity levels measured at sites OAHRLK1073A, OAHLK1090DW, OAHLK1110DW, OAHLK1135DW, OAHLK1153DW, OAHLK1176DW, OAHLK1196DW and OAHNFMORR1 on September 11, 2007.

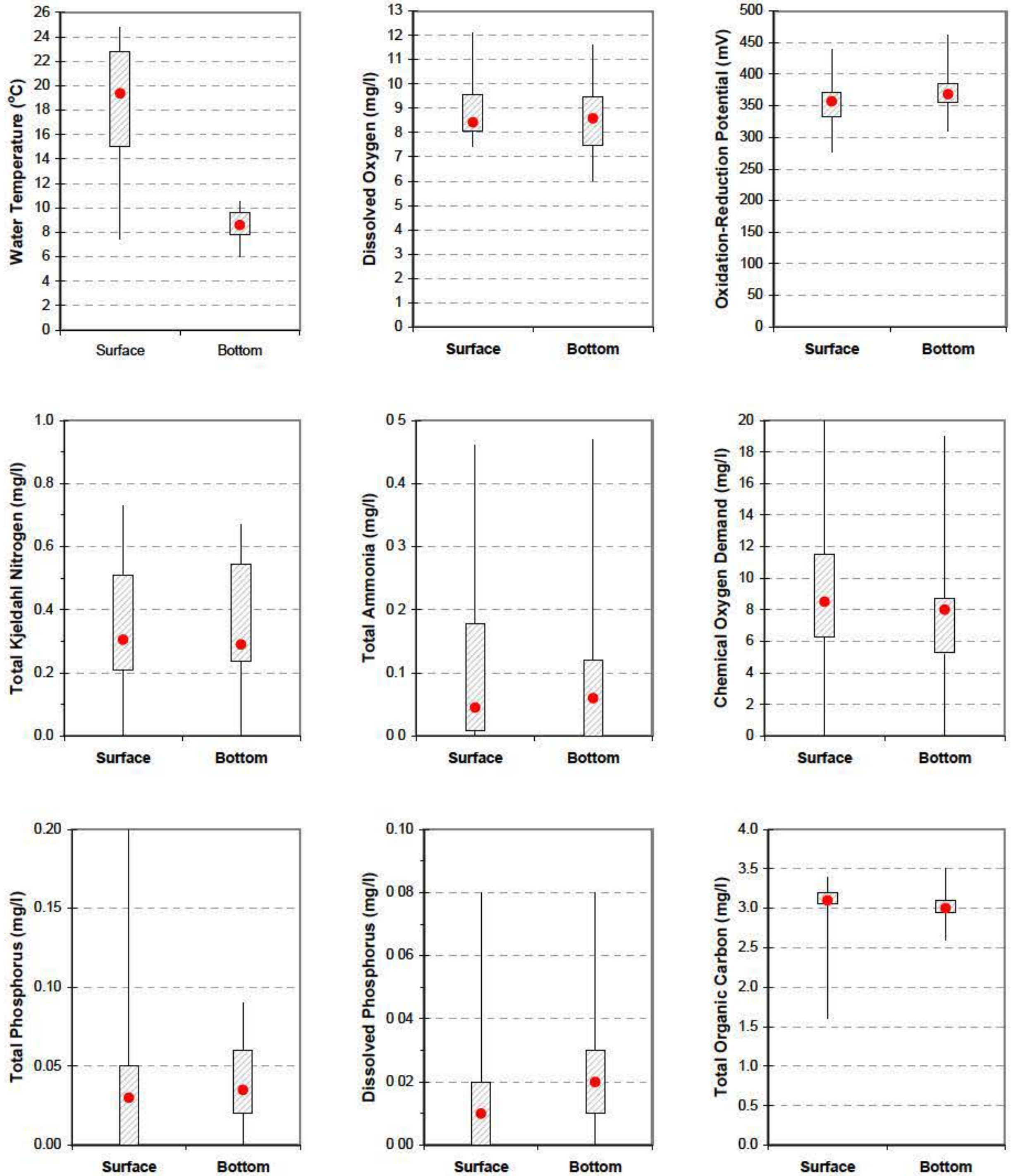


Plate 144. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measured in Oahe Reservoir at site OAHLK1073A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 145. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Oahe Reservoir at site OAHLK1073A during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	7,414,456	2	0 19	0	-----	0	-----	1	0.14	4	0.37	1	0.30	0	-----	1.48
Jul 2004	4,313,125	2	0.14	0	-----	0	-----	2	0.75	3	0.11	0	-----	0	-----	1.25
Aug 2004	164,005,921	4	0.78	0	-----	1	0.07	1	0.02	3	<0.01	1	0.14	0	-----	0.85
Sep 2004	5,604,589	2	0.38	1	0.04	0	-----	1	0.03	3	0.35	0	-----	1	0.20	1.45
May 2005	185,149,541	3	0.96	2	0.01	1	<0.01	1	0.03	0	-----	0	-----	0	-----	0.96
Jun 2005	55,201,496	4	0.58	1	0.8	0	-----	1	0.11	3	0.02	1	0.22	0	-----	1.78
Jul 2005	45,943,019	4	0.31	2	0.04	1	0.35	1	0.04	3	0.02	1	0.25	0	-----	1.73
Aug 2005	37,779,368	5	0.84	1	0.12	0	-----	0	-----	3	0.04	0	-----	0	-----	1.58
Sep 2005	100,194,654	9	0.46	7	0.09	2	0.14	2	0.04	4	0.22	1	0.05	0	-----	2.39
May 2006	186,720,908	8	0 97	3	0.01	0	-----	1	0.01	0	-----	1	0.02	0	-----	1.31
Jun 2006	95,437,433	5	0.76	6	0.18	0	-----	1	0.05	0	-----	0	-----	1	0.01	1.52
Jul 2006	21,592,424	4	0.17	8	0.46	0	-----	1	0.29	2	0.08	0	-----	0	-----	2.25
Aug 2006	52,731,261	5	0.42	2	0.06	1	0.08	1	0.11	3	0.11	1	0.22	0	-----	2.05
Sep 2006	72,290,329	5	0.12	7	0.26	0	-----	1	0.17	2	0.26	1	0.19		-----	2.06
May 2007	116,487,228	7	0.69	5	0.16	2	0.04	1	0.10	0	-----	1	0.01	0	-----	2.09
Jun 2007	688,764,256	4	0.85	6	0.03	2	0.09	1	0.02	0	-----	2	0.02	0	-----	1.03
Jul 2007	112,682,481	9	0.71	7	0.04	0	-----	1	0.12	0	-----	2	0.12	0	-----	1.52
Aug 2007	45,414,995	3	0.04	7	0.08	1	0.11	1	0.35	2	0.07	1	0.35	0	-----	1.63
Sep 2007	211,489,007	5	0.40	10	0.03	1	0.11	2	0.01	5	0.03	1	0.41	0	-----	1.45
Mean*	**116,274,552**	**4.74**	**0.51**	**3.95**	**0.15**	**0.63**	**0.11**	**1.11**	**0.13**	**2.11**	**0.13**	**0.79**	**0.18**	**0.11**	**0.11**	**1.60**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 146. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Oahe Reservoir at site OAHLK1110DW during the 3-year period 2005 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2005	312,053,421	4	0.84	3	0.08	1	<0.01	2	0.06	4	0.02	0	-----	0	-----	1.06
Aug 2005	140,479,427	6	0.30	2	0.08	1	0.07	1	0.29	2	0.05	2	0.22	0	-----	2.16
Sep 2005	162,991,360	5	0.35	4	0.08	1	<0.01	2	0.10	4	0.25	2	0.22	0	-----	2.02
Jun 2006	546,334,257	6	0.97	5	0.01	2	<0.01	1	0.02	3	<0.01	1	<0.01	0	-----	0.64
Jul 2006	83,678,531	6	0.14	3	0.22	0	-----	1	0.19	4	0.20	2	0.24	0	-----	2.19
Aug 2006	300,970,747	6	0.46	5	0.09	0	-----	1	<0.01	3	0.41	1	0.04	0	-----	1.88
Sep 2006	168,663,712	6	0.22	15	0.30	1	0.02	1	0.30	3	0.04	2	0.12	2	<0.01	2.53
Jun 2007	2,874,771,946	6	0.88	7	0.01	2	0.07	1	0.01	0	-----	1	0.03	0	-----	1.05
Jul 2007	61,788,273	8	0.14	6	0.13	1	0.38	1	0.13	1	0.01	1	0.22	0	-----	1.80
Aug 2007	189,011,871	7	0 31	10	0.10	0	-----	1	0.09	1	0.30	1	0.20	1	<0.01	1.99
Sep 2007	127,037,794	5	0.13	8	0.06	1	0.02	1	0.06	6	0.16	1	0.56	1	0.01	1.75
Mean*	**451,616,485**	**5.91**	**0.43**	**6.18**	**0.11**	**0.91**	**0.07**	**1.18**	**0.11**	**2.82**	**0.14**	**1 27**	**0.19**	**0.36**	**<0.01**	**1.73**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 147. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Oahe Reservoir at site OAHLK1153DW during the 3-year period 2005 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	**No. of Genera**	**Percent Comp.**	
Jun 2005	2,103,413	0	-----	0	-----	0	-----	2	0.83	2	0.17	0	-----	0	-----	0.55
Jul 2005	121,465,212	5	0.44	2	0.02	1	0.50	2	0.04	2	<0.01	1	<0.01	0	-----	1.38
Aug 2005	375,380,230	5	0.79	8	0.14	0	-----	2	0.06	5	0.01	1	0.01	0	-----	1.10
Sep 2005	20,836,490	5	0.60	7	0.03	0	-----	1	0.16	5	0.16	1	0.06	0	-----	1.74
Jun 2006	2,880,967,056	8	0.74	13	0.25	1	<0.01	1	<0.01	1	<0.01	1	<0.01	0	-----	0.98
Jul 2006	404,261,840	3	0.87	6	0.03	1	0.02	1	0.03	2	0.03	1	0.02	0	-----	0.70
Aug 2006	116,503,830	7	0 22	10	0.28	1	<0.01	1	0.14	5	0.31	2	0.04	1	<0.01	2.38
Sep 2006	121,255,178	6	0.52	12	0.25	0	-----	1	0.06	4	0.06	1	0.05	2	0.05	2.23
Jun 2007	1,767,149,650	10	0.93	10	0.06	1	<0.01	1	0.01	2	<0.01	1	<0.01	0	-----	0.55
Jul 2007	301,855,009	8	0.53	5	0.06	1	<0.01	1	0.06	2	0.11	1	0.22	1	0.02	1.55
Aug 2007	144,618,019	6	0.12	9	0.18	1	0.19	1	0.11	4	0.08	1	0.26	2	0.06	2.21
Sep 2007	231,862,268	5	0.74	14	0.13	0	-----	2	0.04	5	0.04	1	0.02	1	0.03	2.16
Mean*	**540,688,183**	**5.67**	**0.59**	**8.00**	**0.13**	**0.58**	**0.10**	**1.33**	**0.13**	**3.25**	**0.08**	**1.00**	**0.06**	**0.58**	**0.03**	**1.46**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 148. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Oahe Reservoir at site OAHLK1196DW during the period 2005 through 2006.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2005	120,198,449	6	0 96	2	0.02	0	-----	2	0.01	2	<0.01	0	-----	0	-----	1.63
Jul 2005	630,374,805	8	0.32	12	0.14	0	-----	2	0.31	7	0.20	1	0.04	0	-----	2.24
Aug 2005	166,745,682	5	0.58	2	0.11	0	-----	2	0.26	1	0.05	0	-----	0	-----	1.83
Sep 2005	22,057,409	6	0.88	3	0.03	0	-----	1	0.09	3	<0.01	0	-----	0	-----	1.52
Jun 2006	609,612,839	6	0.98	7	0.01	0	-----	1	<0.01	2	<0.01	1	<0.01	0	-----	0.97
Jul 2006	968,250,327	10	0.98	4	<0.01	1	<0.01	1	<0.01	4	<0.01	1	0.01	1	<0.01	1.43
Aug 2006	2,060,734,486	13	0 95	6	0.02	0	-----	1	0.02	3	<0.01	2	0.01	1	<0.01	1.81
Sep 2006	852,699,287	13	0 95	8	0.03	0	-----	1	0.01	2	<0.01	1	<0.01	1	<0.01	1.82
Jun 2007	1,819,909,690	10	0 91	10	0.07	1	<0.01	1	0.01	2	0.01	0	-----	0	-----	0.67
Jul 2007	800,167,337	10	0.65	8	0.02	0	-----	1	0.04	1	0.15	2	0.15	0	-----	1.49
Aug 2007	1,497,597,364	8	0.91	8	0.02	1	<0.01	0	-----	1	0.02	1	0.03	3	0.01	1.65
Sep 2007	887,246,429	9	0.94	8	0.03	0	-----	1	0.01	3	<0.01	1	0.02	2	<0.01	0.91
Mean*	**869,632,842**	**8.67**	**0.83**	**6.50**	**0.04**	**0.25**	**<0.01**	**1 17**	**0.07**	**2.58**	**0.04**	**0.83**	**0.03**	**0.67**	**<0.01**	**1.50**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 149. Dominant taxa present in phytoplankton grab samples collected at the near-dam monitoring site (site OAHLK1073A) at OAHE Reservoir during the 4-year period 2004 through 2007.

Date	Division	Dominant Taxa*	Percent of Total Biovolume
June 2004	Cyanobacteria	*Anabaena spp.*	0.34
	Pyrrophyta	*Peridinium inconspicuum*	0.30
	Bacillariophyta	*Fragilaria construens*	0.17
	Cryptophyta	*Rhodomonas minuta*	0.14
July 2004	Cryptophyta	*Rhodomonas minuta*	0.59
	Cryptophyta	*Cryptomonas spp.*	0.16
	Bacillariophyta	*Asterionella formossa*	0.12
August 2004	Bacillariophyta	*Fragilaria crotonensis*	0.75
	Pyrrophyta	*Ceratium hirundinella*	0.13
September 2004	Bacillariophyta	*Aulacoseira islandica*	0.25
	Cyanobacteria	*Anabaena circinalis*	0.23
	Bacillariophyta	*Cyclotella spp.*	0.13
	Cyanobacteria	*Anabaena flos-aquae*	0.11
May 2005	Bacillariophyta	*Asterionella formossa*	0.60
	Bacillariophyta	*Fragilaria construens*	0.33
June 2005	Bacillariophyta	*Stephanodiscus spp.*	0.29
	Pyrrophyta	*Peridinium spp.*	0.22
	Bacillariophyta	*Fragilaria crotonensis*	0.14
	Bacillariophyta	*Asterionella formossa*	0.14
	Cryptophyta	*Cryptomonas spp.*	0.11
July 2005	Chrysophyta	*Dinobryon sertularia*	0.35
	Pyrrophyta	*Ceratium hirundinella*	0.25
	Bacillariophyta	*Stephanodiscus hantzschii*	0.20
August 2005	Bacillariophyta	*Asterionella formossa*	0.41
	Bacillariophyta	*Synedra spp.*	0.23
	Bacillariophyta	*Navicula spp.*	0.14
	Chlorophyta	*Chlamydomonas spp.*	0.12
September 2005	Bacillariophyta	*Aulacoseira granulata*	0.22
	Cyanobacteria	*Anabaena spp.*	0.18
	Chrysophyta	*Dinobryon sertularia*	0.13
May 2006	Bacillariophyta	*Fragilaria crotonensis*	0.32
	Bacillariophyta	*Asterionella formossa*	0.26
	Bacillariophyta	*Fragilaria spp.*	0.22
June 2006	Bacillariophyta	*Fragilaria crotonensis*	0.39
	Bacillariophyta	*Asterionella formossa*	0.26
	Chlorophyta	*Cosmarium spp.*	0.17
July 2006	Cryptophyta	*Rhodomonas minuta*	0.29
	Chlorophyta	*Cosmarium spp.*	0.17
	Chlorophyta	*Golenkinia radiata*	0.11
August 2006	Bacillariophyta	*Fragilaria crotonensis*	0.27
	Pyrrophyta	*Ceratium hirundinella*	0.22
	Cryptophyta	*Rhodomonas minuta*	0.11
September 2006	Cyanobacteria	*Anabaena spp.*	0.23
	Pyrrophyta	*Ceratium hirundinella*	0.19
	Chlorophyta	*Cosmarium spp.*	0.19
	Cryptophyta	*Rhodomonas minuta*	0.17

Table. 149. (Continued)

May 2007	Bacillariophyta	*Stephanodiscus sp.*	0.26
	Bacillariophyta	*Fragilaria capucina*	0.20
	Bacillariophyta	*Cyclotella sp.*	0.13
June 2007	Bacillariophyta	*Fragilaria capucina*	0.72
	Bacillariophyta	*Asterionella formossa*	0.12
July 2007	Bacillariophyta	*Fragilaria capucina*	0.46
	Bacillariophyta	*Tabellaria flocculosa*	0.12
	Cryptophyta	*Rhodomonas sp.*	0.12
	Pyrrophyta	*Ceratium hirundinella*	0.12
August 2007	Cryptophyta	*Rhodomonas sp.*	0.35
	Pyrrophyta	*Ceratium cornutum*	0.19
	Pyrrophyta	*Ceratium hirundinella*	0.16
	Chrysophyta	*Dinobryon sp.*	0.10
September 2007	Pyrrophyta	*Ceratium hirundinella*	0.40
	Bacillariophyta	*Fragilaria capucina*	0.37
	Chrysophyta	*Dinobryon sp.*	0.11

* Dominant taxa are genera or species (depending on identification level) that comprised more than 10% of the total sample biovolume.

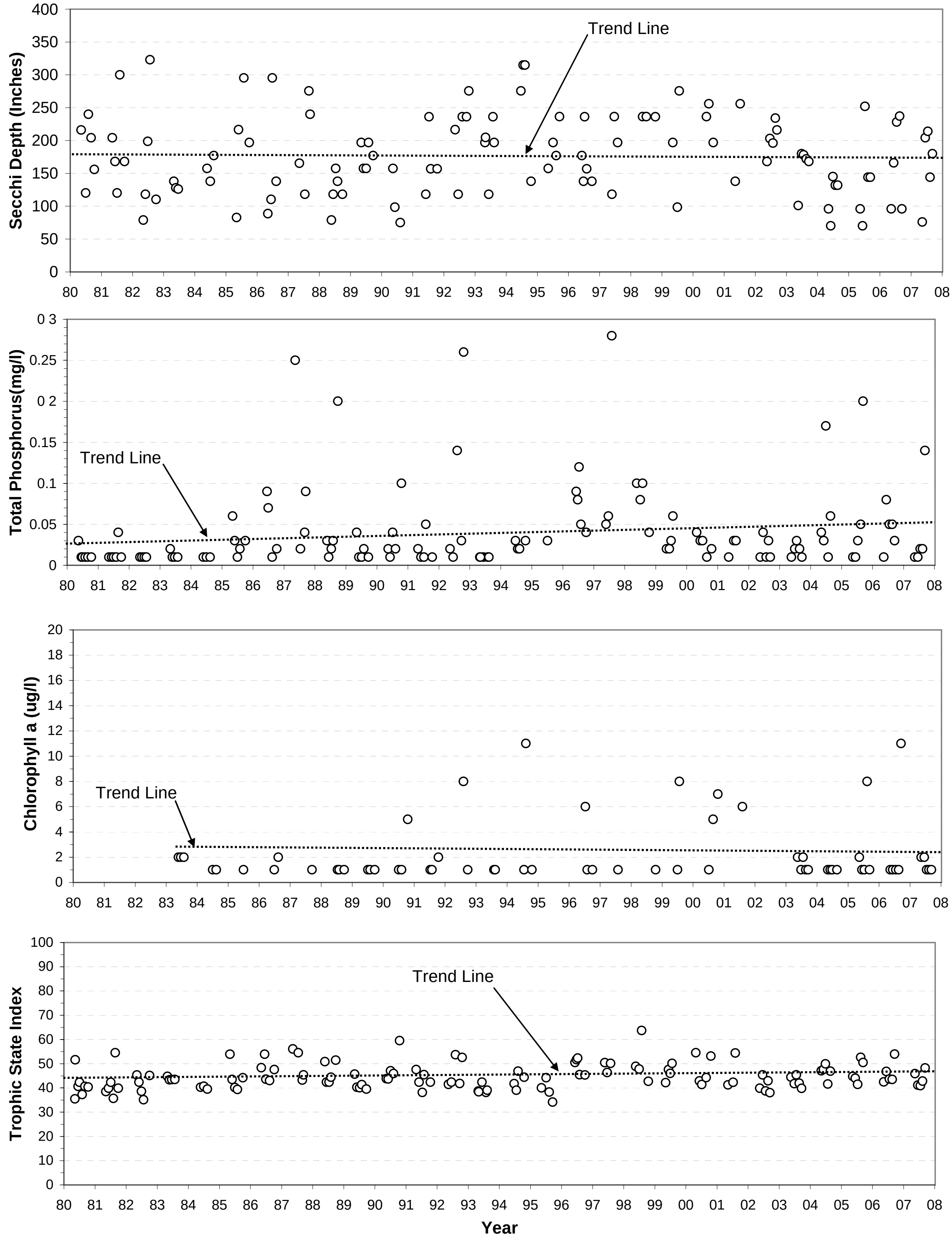


Plate 150. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Oahe Reservoir at the near-dam, ambient site (i.e., site OAHLK1073A) over the 28-year period of 1980 to 2007.

Plate 151. Summary of monthly (May through September) water quality conditions monitored in the Missouri River near Bismarck, North Dakota (Site OAHNFMORRR1) during the 3-year period 2005 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Stream Flow (cfs)	10	15	17,053	16,000	11,900	26,800	-----	-----	-----
Water Temperature (C)	0.1	15	19.4	18.7	14.8	25.5	18.3(1) 23.9(1) 26.7(1)	8 1 0	53% 7% 0%
Dissolved Oxygen (mg/l)	0.1	15	9.1	8.8	8.1	10.5	≥ 7.0(2) ≥ 6.0(2) ≥ 5.0(2)	0 0 0	0% 0% 0%
Dissolved Oxygen (% Sat.)	0.1	15	102.7	102.2	93.6	109.7	-----	-----	-----
Specific Conductance (umho/cm)	1	15	614	614	581	653	-----	-----	-----
pH (S.U.)	0.1	15	8.3	8.3	8.0	8.7	≥6.6 - ≤8.6(3) ≥6.5 - ≤8.8(3) ≥6.5 - ≤9.0(3)	1 0 0	7% 0% 0%
Turbidity (NTUs)	0.1	15	12.9	7.6	0.4	49.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	15	398	372	303	531	-----	-----	-----
Alkalinity, Total (mg/l)	7	15	160	155	140	185	-----	-----	-----
Ammonia N, Total (mg/l)	0.01	15	-----	0.03	n.d.	0.08	3.88(4,5) 1.0(4,6)	0 0	0% 0%
Carbon, Total Organic (mg/l)	0.05	14	3.0	3.2	n.d.	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	11	10	11	2	16	-----	-----	-----
Chloride (mg/l)	1	10	9	9	8	10	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	14	442	425	390	620	1,750(7)	0	0%
Iron, Dissolved (ug/l)	40	15	-----	n.d.	n.d.	40	-----	-----	-----
Iron, Total (ug/l)	40	15	519	470	190	1,614	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	15	0.3	0.3	n.d.	0.7	-----	-----	-----
Manganese, Dissolved (ug/l)	1	15	-----	3	n.d.	10	-----	-----	-----
Manganese, Total (ug/l)	1	15	19	16	10	41	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	14	0.07	0.08	n.d.	0.11	10(7)	0	0%
Phosphorus, Total (mg/l)	0.01	15	0.10	0.04	n.d.	0.29	-----	-----	-----
Phosphorus, Total Dissolved (mg/l)	0.01	15	-----	0.02	n.d.	0.17	-----	-----	-----
Orthophosphorus, Dissolved (mg/l)	0.01	15	-----	n.d.	n.d.	0.06	-----	-----	-----
Sulfate (mg/l)	1	14	169	180	141	190	875(7)	0	0%
Suspended Solids, Total (mg/l)	4	15	16	15	6	27	53(5,8) 30(6,8)	0 0	0% 0%

n.d. = Not detected.

* Results are for samples collected at the surface.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) Numeric temperature criteria are given in South Dakota's water quality standards for coldwater permanent fish life propagation (18.3 C), coldwater marginal fish life propagation (23.9 C), and warmwater permanent fish life propagation (26.7 C).

(2) Numeric dissolved oxygen criteria are given in South Dakota's water quality standards for coldwater permanent fish life propagation (7 mg/l in spawning areas during spawning season and 6 mg/l at other times), coldwater marginal fish life propagation (5 mg/l), and warmwater permanent fish life propagation (5 mg/l).

(3) Numeric pH criteria are given in South Dakota's water quality standards for coldwater permanent fish life propagation (≥6.6 - ≤8.6), coldwater marginal fish life propagation (≥65 - ≤8.8), and warmwater permanent fish life propagation (≥6.5 - ≤9.0).

(4) Total ammonia criteria pH and temperature dependent – criteria listed are for the median pH and temperature values. Listed criteria are those defined by South Dakota's water quality standards for the protection of coldwater permanent fish life propagation.

(5) Acute criterion for aquatic life.

(6) Chronic criterion for aquatic life.

(7) Daily maximum criterion for domestic water supply.

(8) Numeric suspended solids criteria given in South Dakota's water quality standards for coldwater permanent fish life propagation.

Plate 152. Summary of annual (May and August) water quality conditions monitored in the Missouri River at Bismarck, North Dakota at monitoring Station OAHNFMORR1 (NF1) during the 3-year period 2005 through 2007**.**

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Hardness, Dissolved (mg/l)	0.4	2	200	200	181	219	-----	-----	-----
Aluminum, Dissolved (ug/l)	50	1	-----	n.d.	n.d.	n.d.	-----	-----	-----
Antimony, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	5.6(3)	0	0%
Arsenic, Dissolved (ug/l)	1	1	-----	1	1	1	340(1) 150(2) 0.018(3)	0 0 1	0% 0% 100%
Beryllium, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	4(3)	0	0%
Cadmium, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	9.9(1) 4.2(2)	0 0	0% 0%
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	3,180(1) 152(2)	0 0	0% 0%
Copper, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	26.9(1) 16.9(2)	0 0	0% 0%
Lead, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	197(1) 7.7(2)	0 0	0% 0%
Mercury, Dissolved (ug/l)	0.02	2	-----	n.d.	n.d.	n.d.	1.4(1) 0.05(3)	0 0	0% 0%
Mercury, Total (ug/l)	0.02	2	-----	n.d.	n.d.	n.d.	0.012(2)	b.d.	b.d.
Nickel, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	843(1) 94(2) 610(3)	0 0 0	0% 0% 0%
Selenium, Total (ug/l)	1	1	-----	n.d.	n.d.	n.d.	4.6(2) 170(3)	0 0	0% 0%
Silver, Dissolved (ug/l)	1	2	-----	n.d.	n.d.	n.d.	14.7(1)	0	0%
Zinc, Dissolved (ug/l)	10	1	3	3	3	3	216(1,2) 7,400(3)	0 0	0% 0%
Pesticide Scan (ug/l)****	0.05	1	-----	n.d.	n.d.	n.d.	*****	0	0%

n.d. = Not detected. b.d. = Criteria below detection limit.

* Results are for samples collected at the surface. Metals samples were collected on August 28, 2006 and August 20, 2007. Pesticide sample was collected on May 25, 2006.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported.

*** (1) Acute criterion for aquatic life.
(2) Chronic criterion for aquatic life.
(3) Human health criterion.

Note: South Dakota's water quality standards criteria for the metals cadmium, chromium, copper, lead, nickel, silver, and zinc are dependent upon hardness – criteria listed are based on the median hardness value.

**** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides do not have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

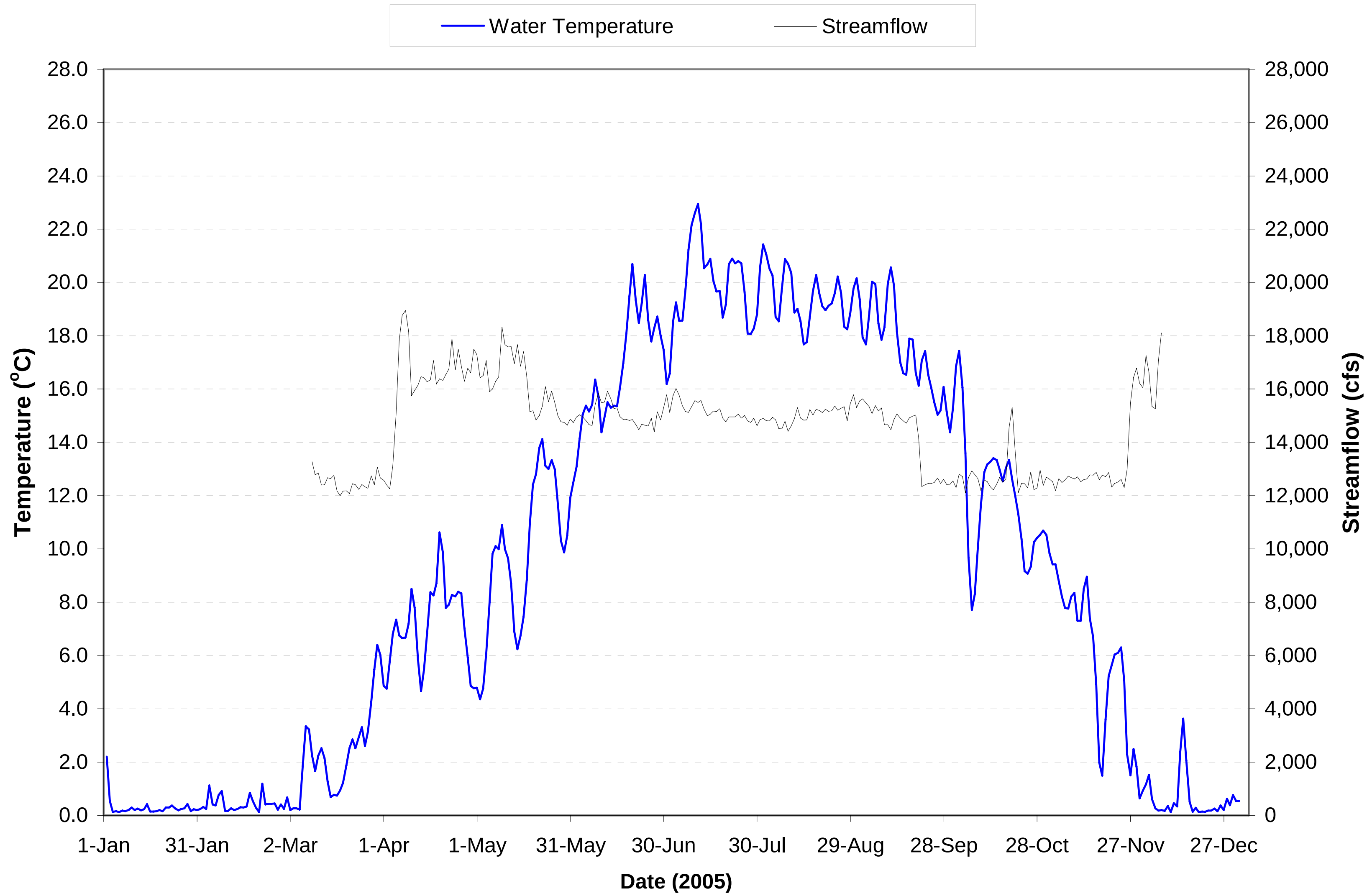


Plate 153. Mean daily water temperature and discharge of the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) for 2005. Mean daily temperatures and discharges based on hourly measurements recorded on the Missouri River at Bismarck, North Dakota (USGS gaging station 06342500).

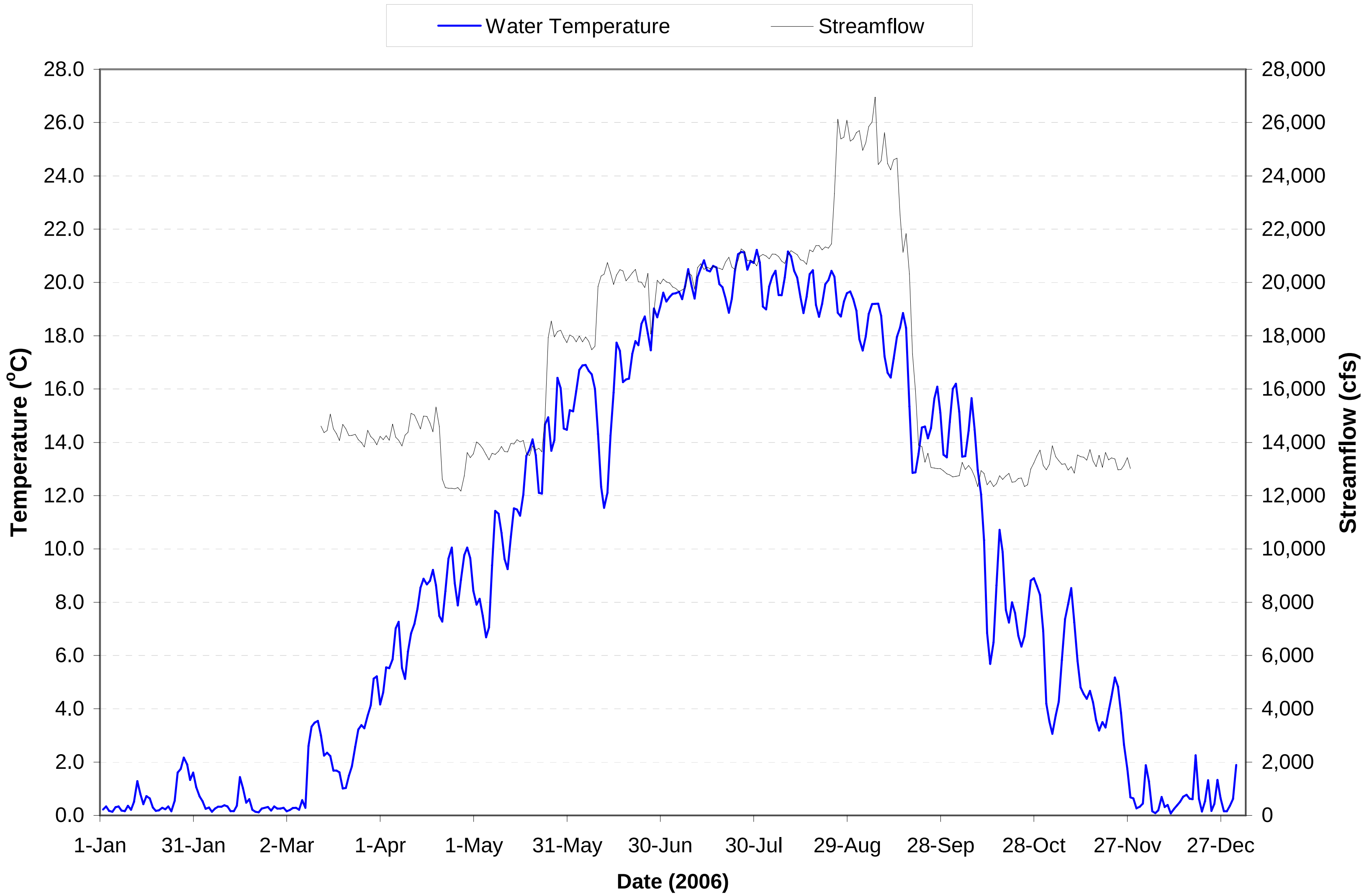


Plate 154. Mean daily water temperature and discharge of the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) for 2006. Mean daily temperatures and discharges based on hourly measurements recorded on the Missouri River at Bismarck, North Dakota (USGS gaging station 06342500).

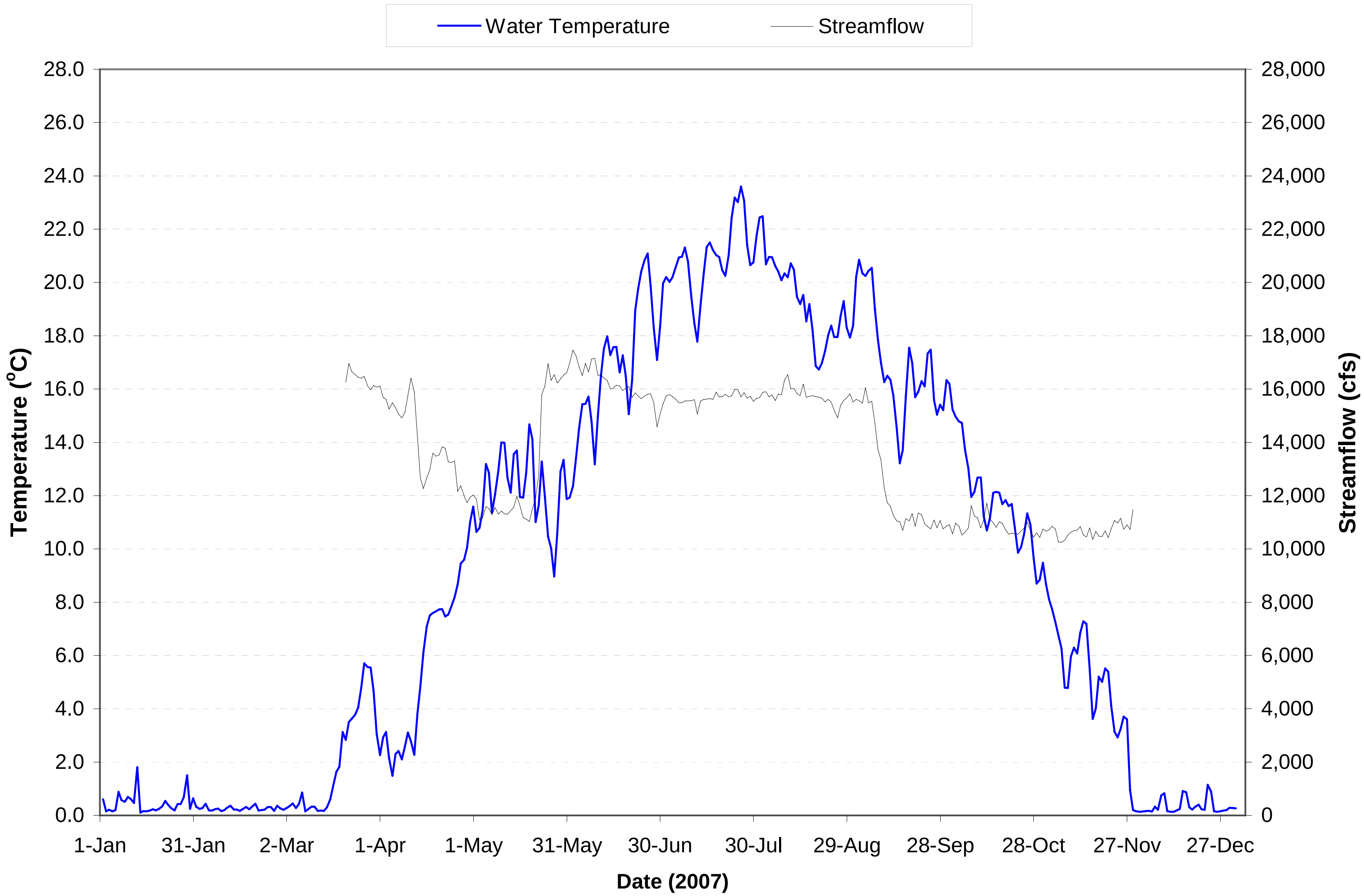


Plate 155. Mean daily water temperature and discharge of the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) for 2007. Mean daily temperatures and discharges based on hourly measurements recorded on the Missouri River at Bismarck, North Dakota (USGS gaging station 06342500).

Plate 156. Summary of water quality conditions monitored on water discharged through Oahe Dam (i.e., site OAHPP1) during the 4-year period of 2004 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	38	20,367	18,900	0	48,097	-----	-----	-----
Water Temperature (C)	0.1	34	12.1	14.4	1.5	23.2	18.3	10	29%
Dissolved Oxygen (mg/l)	0.1	34	10.0	9.8	7.1	13.6	≥ 7.0 ≥ 6.0	0 0	0% 0%
Dissolved Oxygen (% Sat.)	0.1	34	94.8	95.9	80.8	105.7	-----	-----	-----
Specific Conductance (umho/cm)	1	34	651	674	357	736	-----	-----	-----
pH (S.U.)	0.1	27	8.3	8.3	8.0	8.7	≥6.6 & ≤8.6	1	<1%
Oxidation-Reduction Potential	1	16	403	397	274	541	-----	-----	-----
Alkalinity, Total (mg/l)	7	38	172	170	140	205	-----	-----	-----
Ammonia, Total (mg/l)	0.01	38	-----	0.04	n.d.	0.30	3.15 [1,2], 1.44 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	36	3.0	3.0	1.2	4.3	-----	-----	-----
Chloride (mg/l)	1	19	10	11	9	14	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	8	7	n.d.	19	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	38	466	457	404	615	1,750[5]	0	0%
Hardness, Total (mg/l)	0.4	2	224	224	213	235	-----	-----	-----
Iron, Dissolved (ug/l)	40	29	-----	n.d.	n.d.	50	-----	-----	-----
Iron, Total (ug/l)	40	30	163	67	n.d.	763	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	38	0.4	0.3	n.d.	1.8	-----	-----	-----
Manganese, Dissolved (ug/l)	1	29	-----	n.d.	n.d.	16	-----	-----	-----
Manganese, Total (ug/l)	1	30	24	11	n.d.	110	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	38	-----	n.d.	n.d.	0.09	10[6]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	23	-----	n.d.	n.d.	0.20	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	38	-----	0.03	n.d.	0.29	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	37	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	38	197	199	163	230	875[6]	0	0%
Suspended Solids, Total (mg/l)	4	38	-----	n.d.	n.d.	91	53[2] 30[3]	1 3	3% 8%
Antimony, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	0.6	6[6]	0	0%
Arsenic, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	1	340[2], 150[3], 50[6]	0	0%
Barium, Dissolved (ug/l)	5	1	43	43	43	43	1,000[6]	0	0%
Beryllium, Dissolved (ug/l)	2	3	-----	n.d.	n.d.	n.d.	4[6]	0	0%
Cadmium, Dissolved (ug/l)	0.2	6	-----	n.d.	n.d.	n.d.	11.2[2], 4.6[3], 5[6]	0	0%
Chromium, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	3,490[2], 167[3], 100[6]	0	0%
Copper, Dissolved (ug/l)	2	6	3	3	n.d.	6	29.9[2], 18.6[3], 1,000[6]	0	0%
Lead, Dissolved (ug/l)	0.5	6	-----	n.d.	n.d.	n.d.	228[2], 8.9[3], 15[6]	0	0%
Mercury, Dissolved (ug/l)	0.02	6	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.02	6	-----	n.d.	n.d.	n.d.	1.7[2], 0.91[3], 0.05[6]	0	0%
Nickel, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	928[2], 103[3], 100[6]	0	0%
Selenium, Total (ug/l)	1	6	-----	n.d.	n.d.	n.d.	20[2], 5[3], 50[6]	0	0%
Silver, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	n.d.	14.7	0	0%
Thallium, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	n.d.	0.47[6]	0	0%
Zinc, Dissolved (ug/l)	10	6	-----	3	n.d.	11	237[2,3], 9,100[6]	0	0%
Pesticide Scan (ug/l)***	0.05	4	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** [1]Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values of 8.3 and 11.0 respectively.
[2] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[3] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[6]Human health criterion for surface waters.
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness of 224 mg/l.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

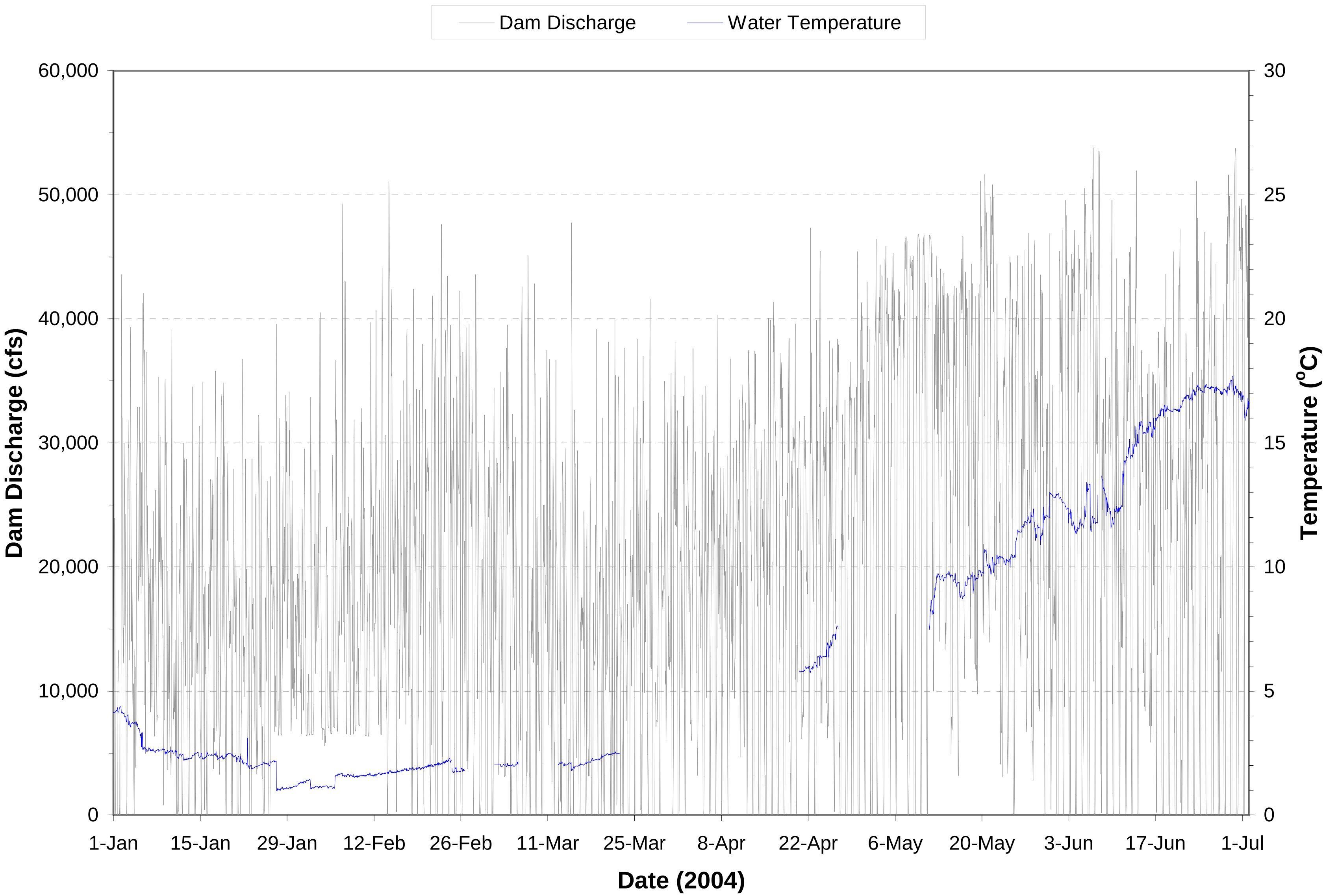


Plate 157. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

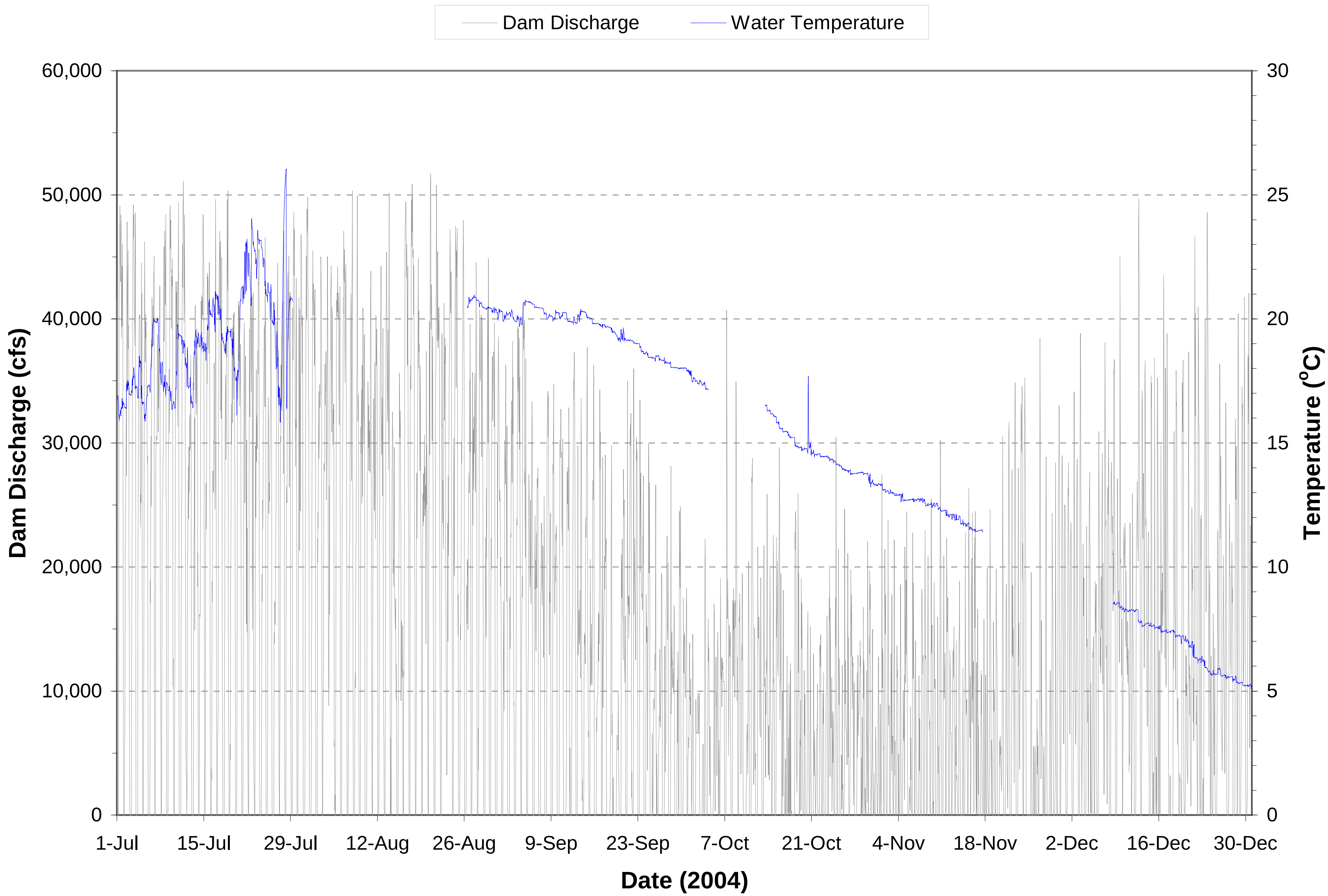


Plate 158. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

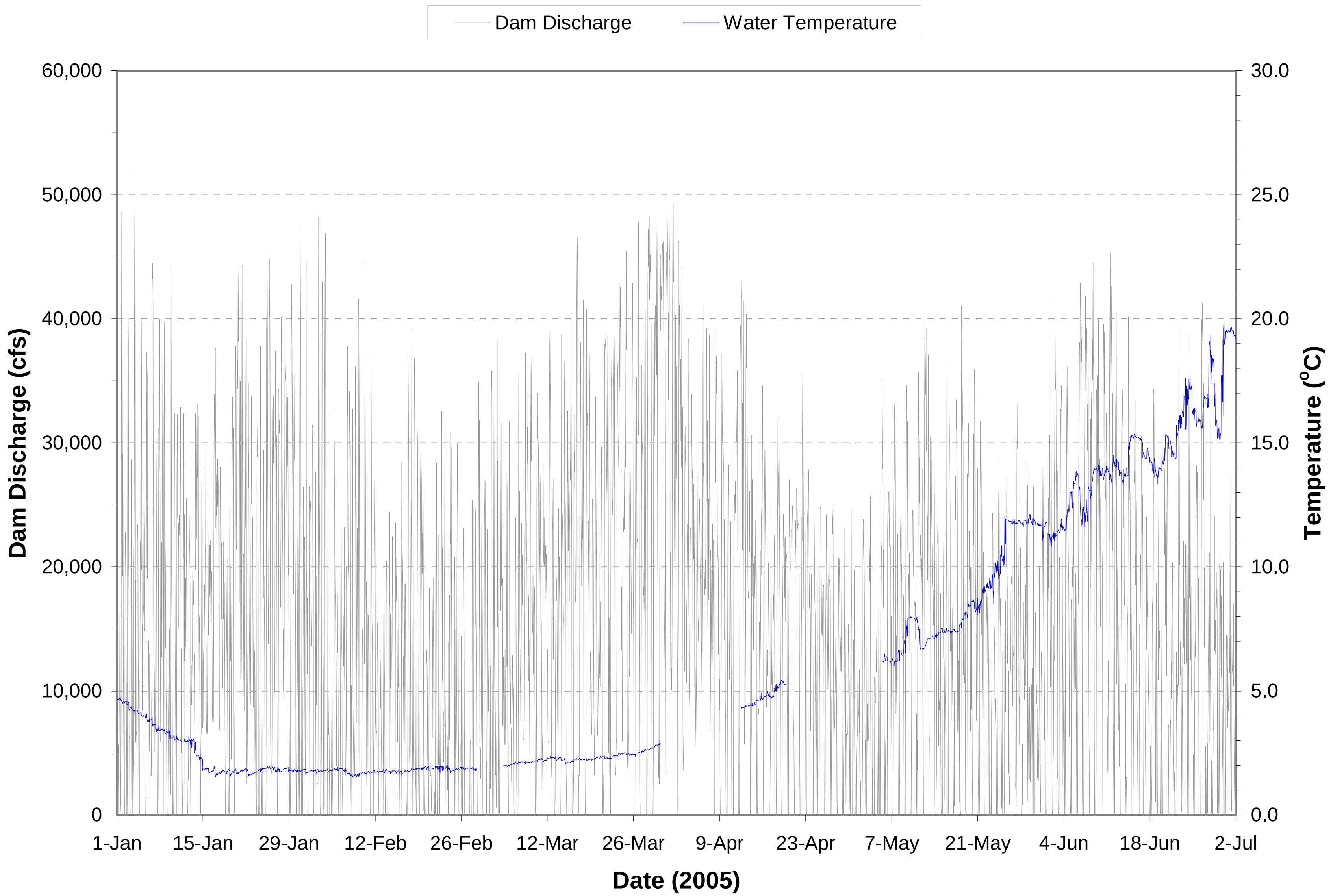


Plate 159. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

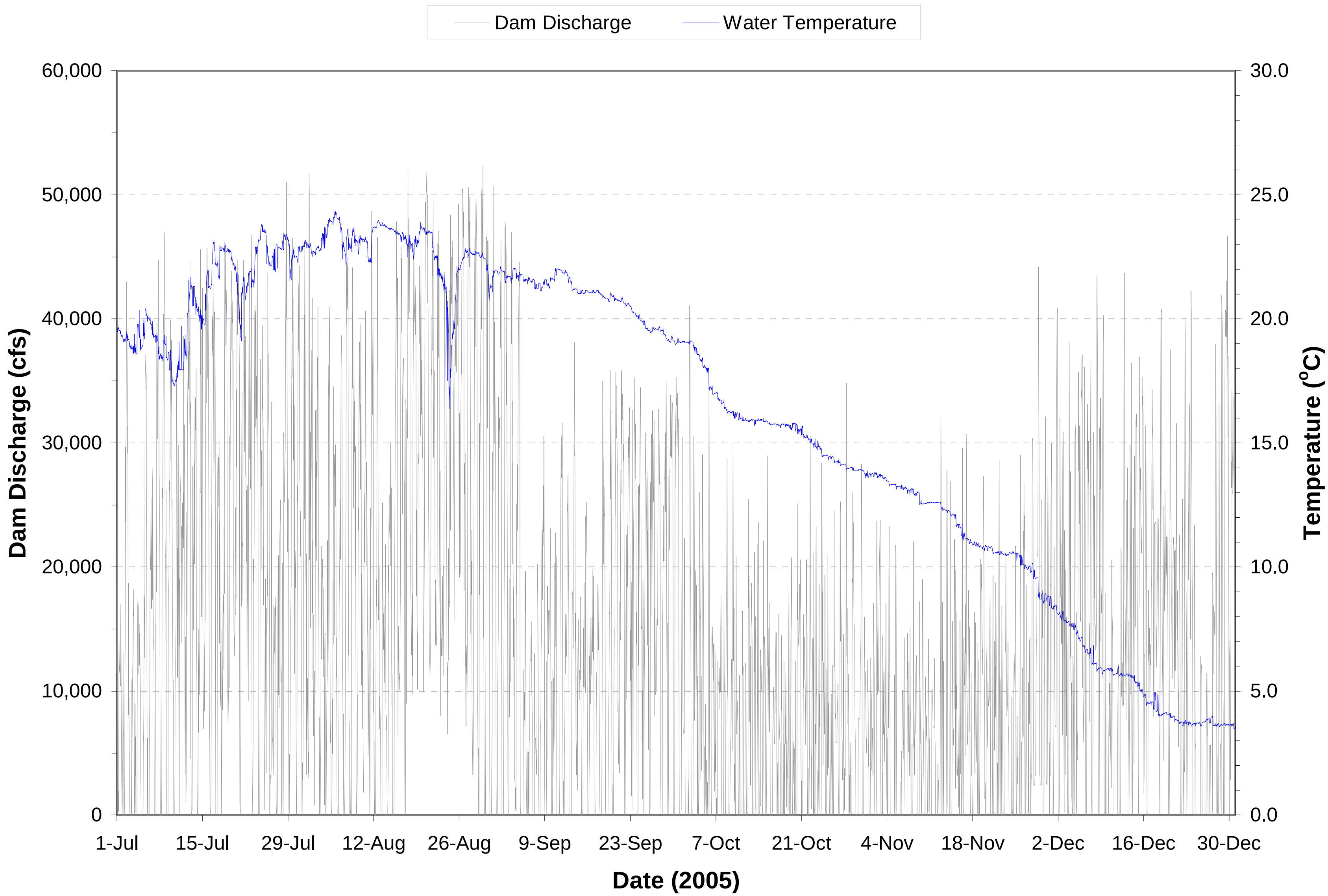


Plate 160. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2005.

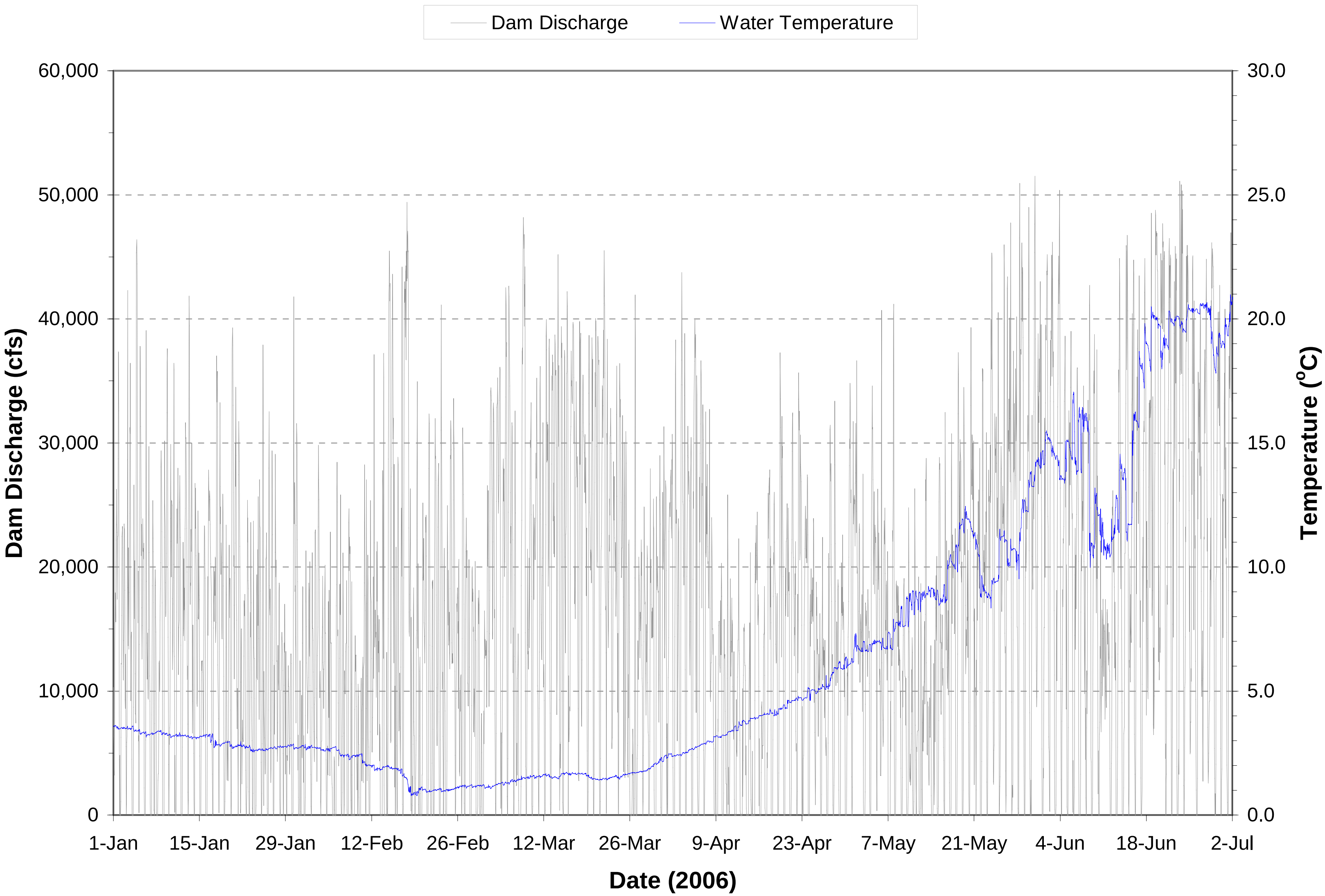


Plate 161. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2006.

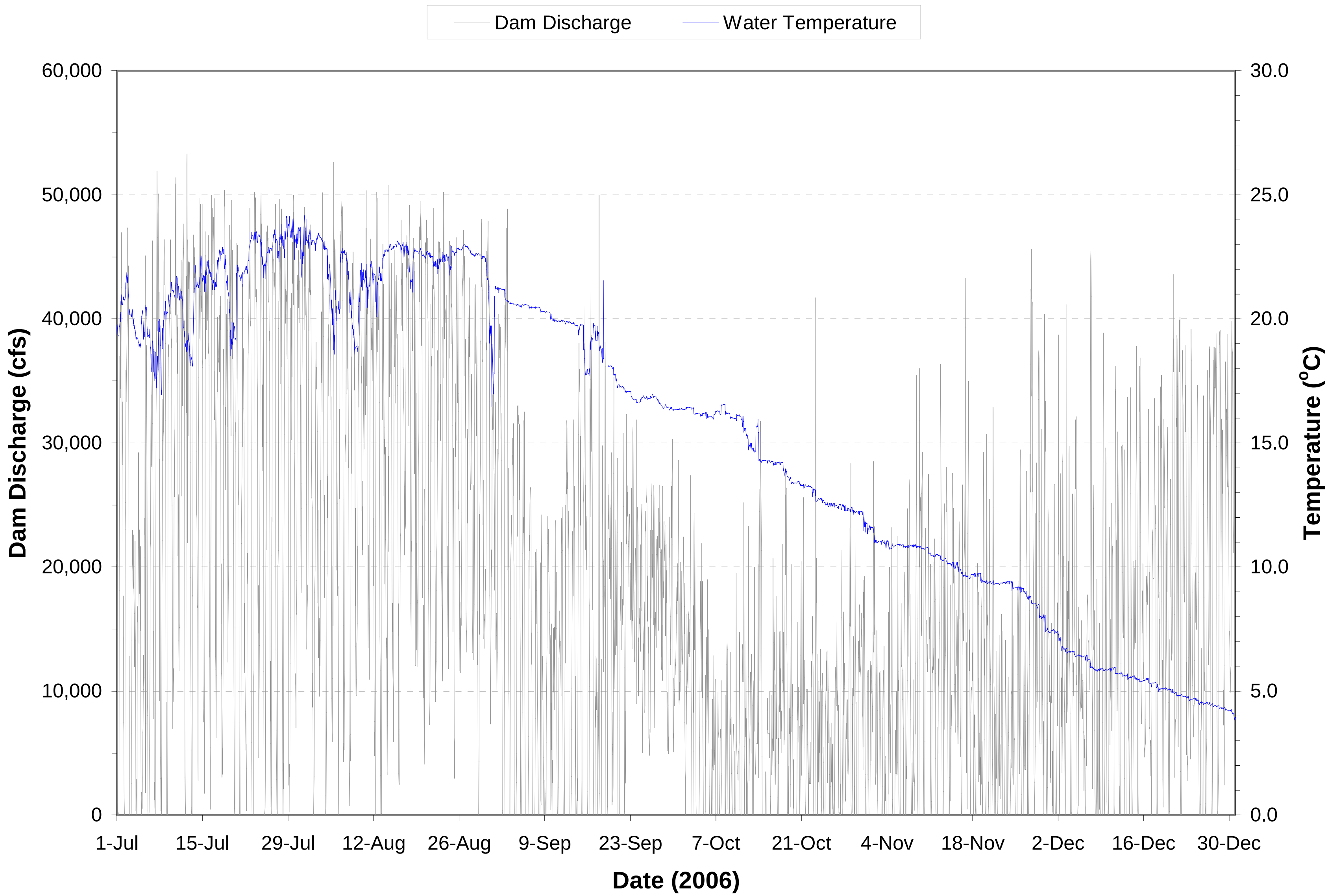


Plate 162. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2006.

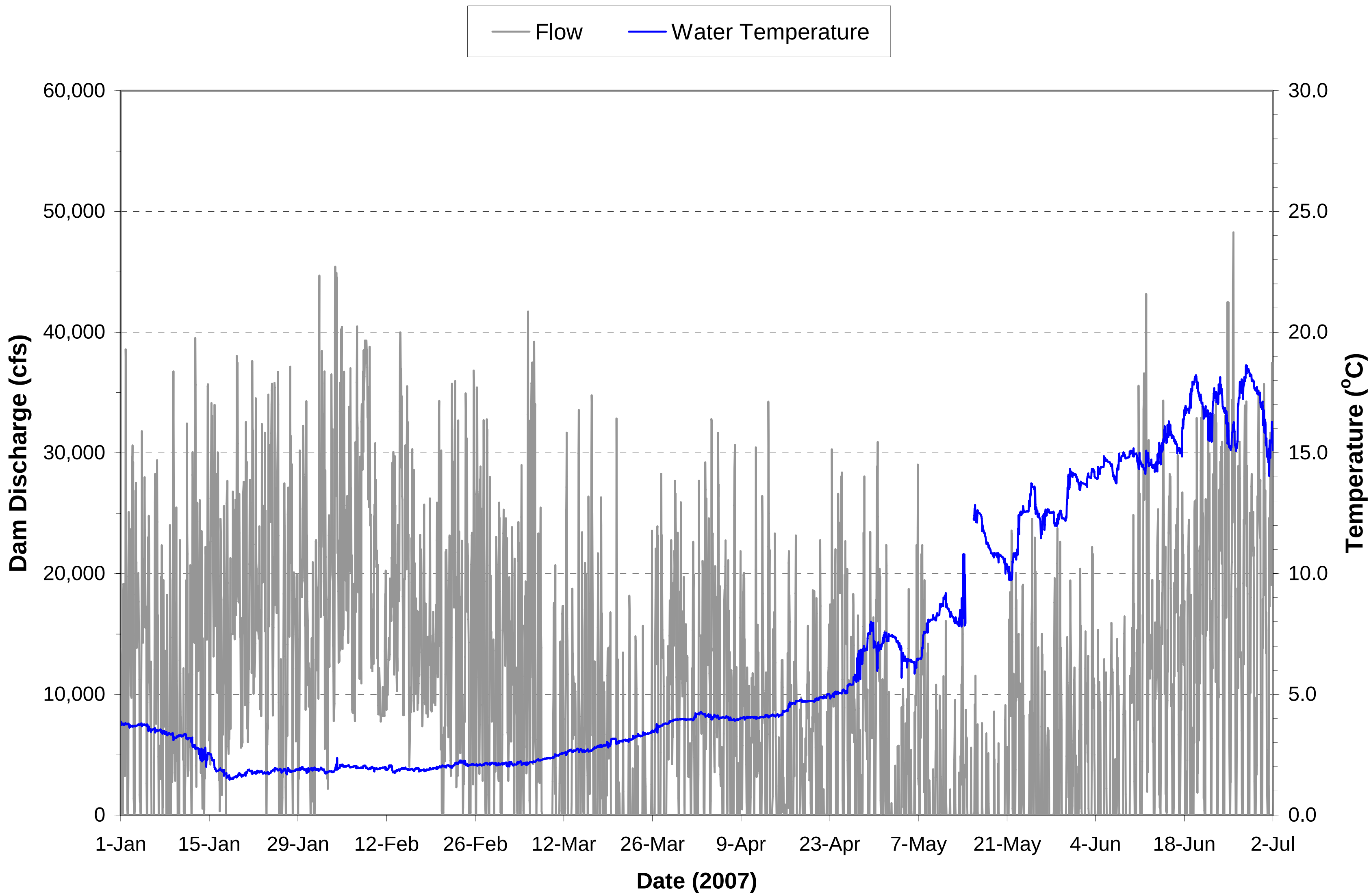


Plate 163. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2007.

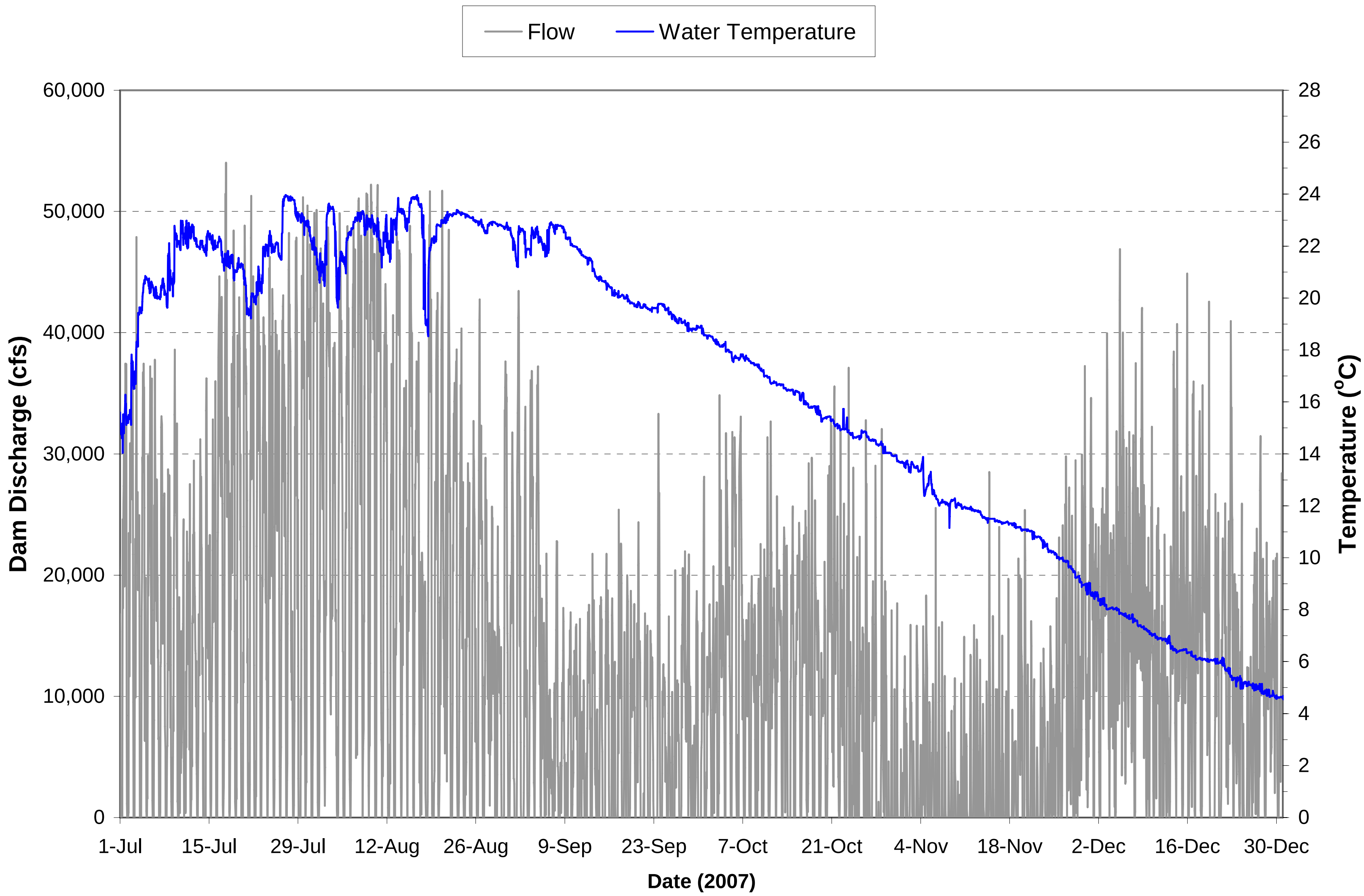


Plate 164. Hourly discharge and water temperature monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2007.

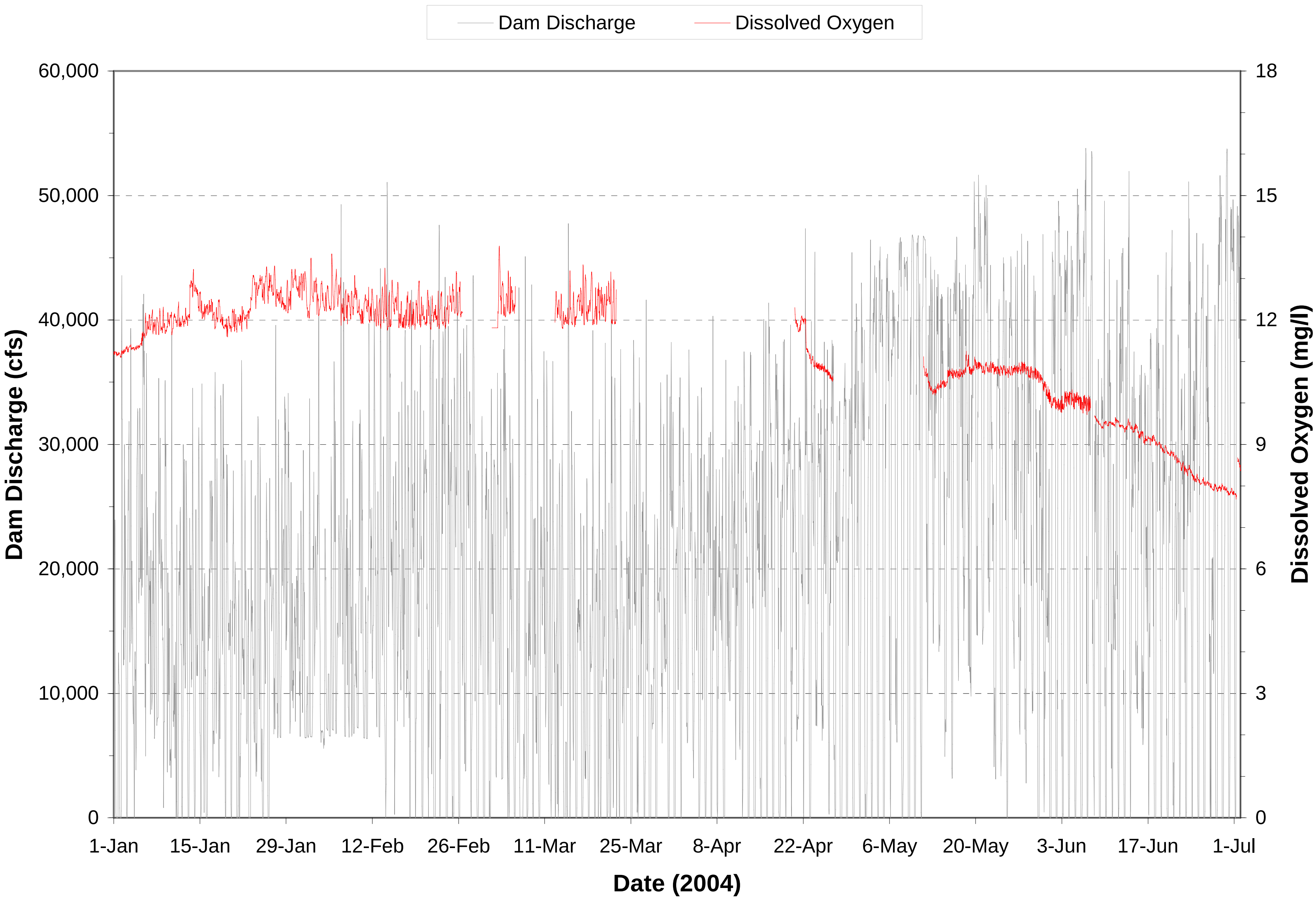


Plate 165. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

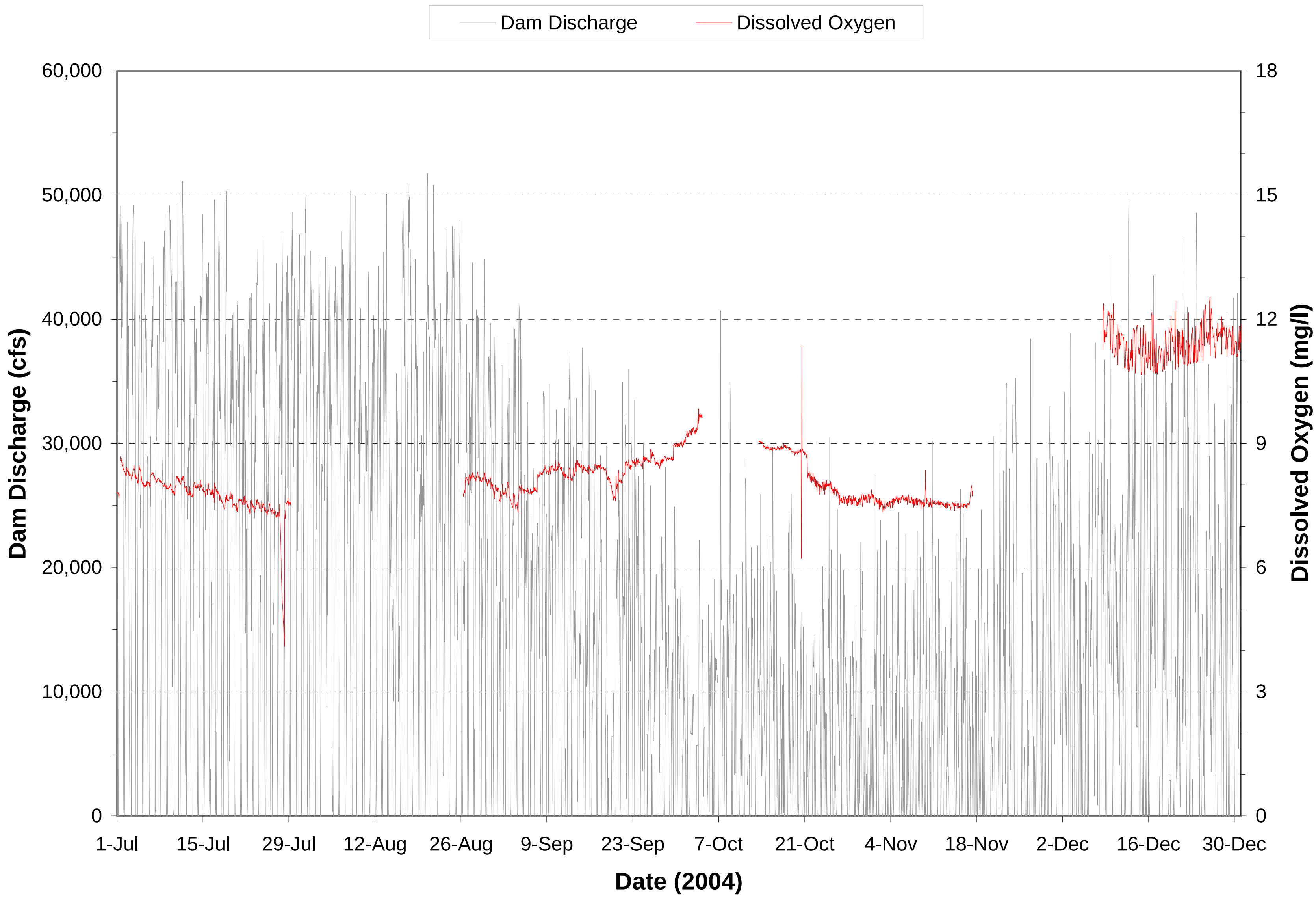


Plate 166. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

Plate 167. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

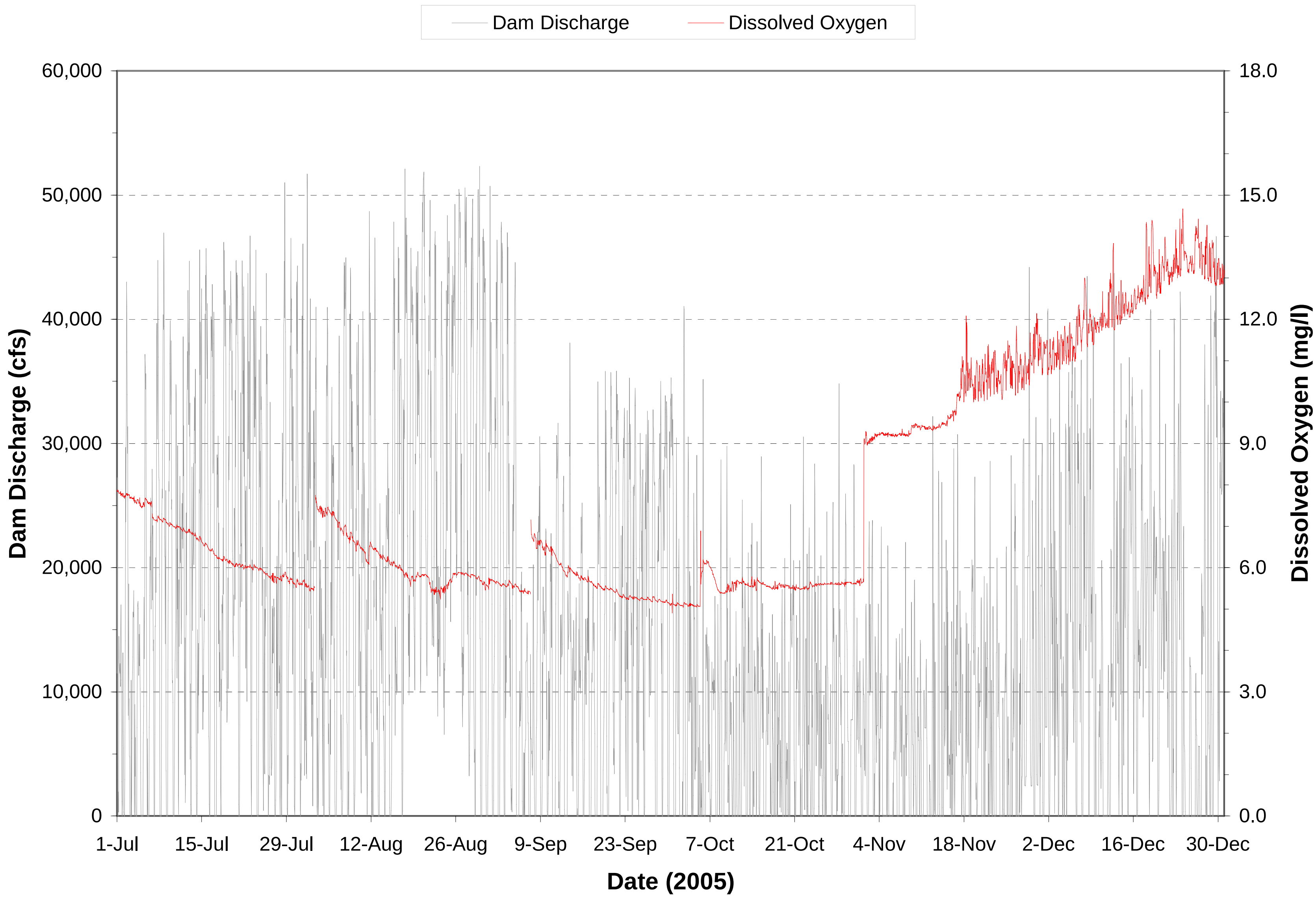


Plate 168. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

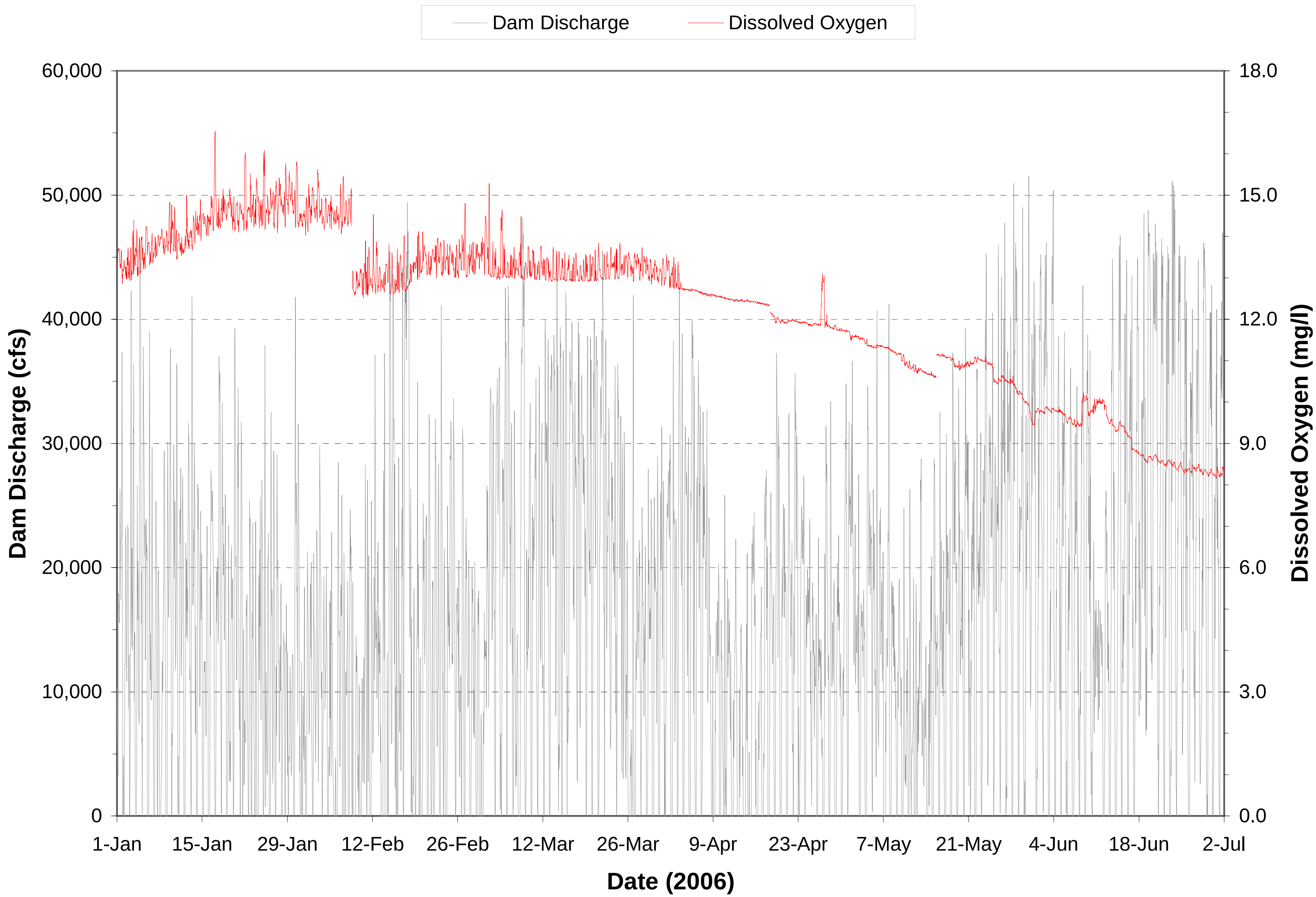


Plate 169. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

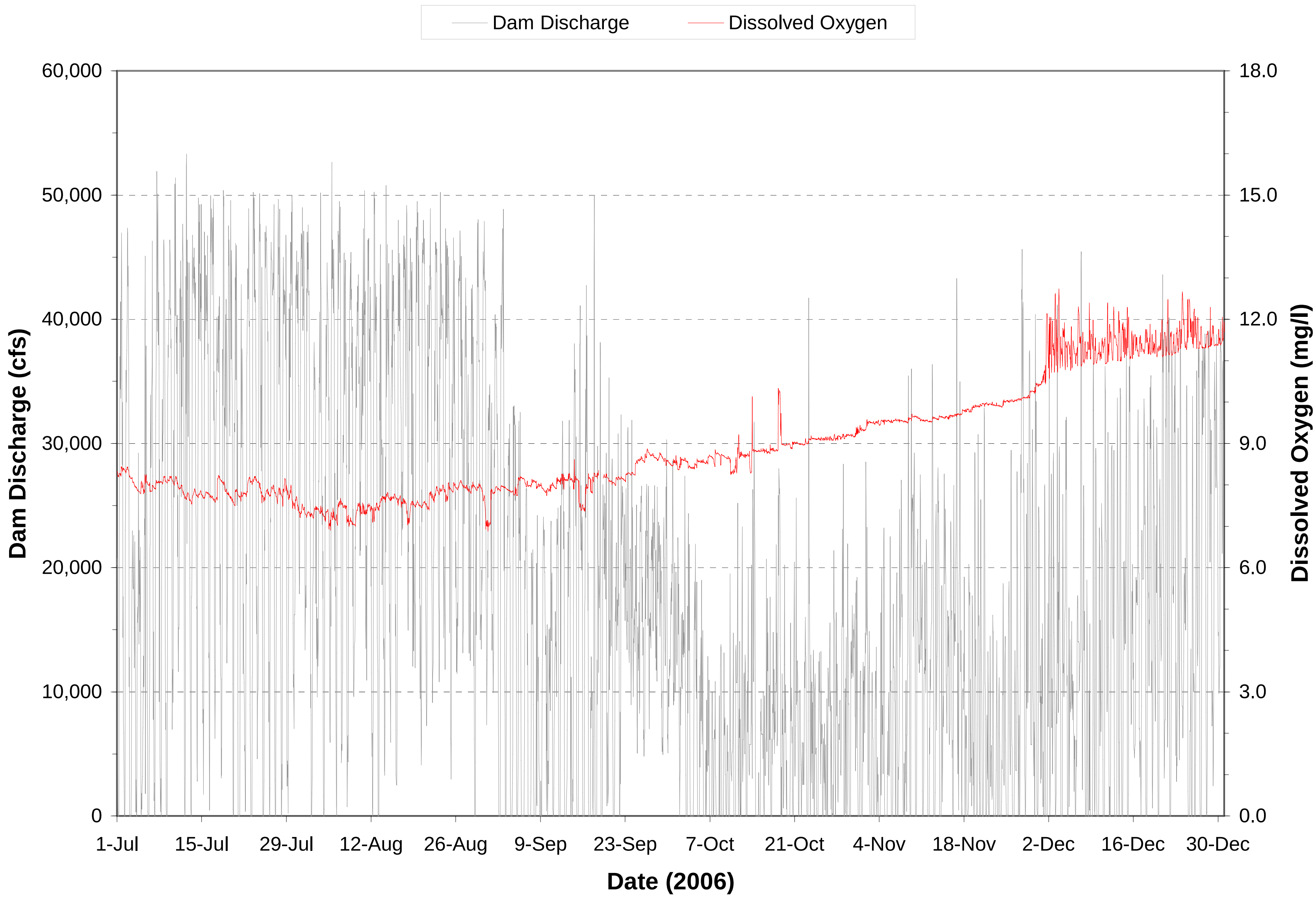


Plate 170. Hourly discharge and dissolved oxygen monitored at the Oahe Powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

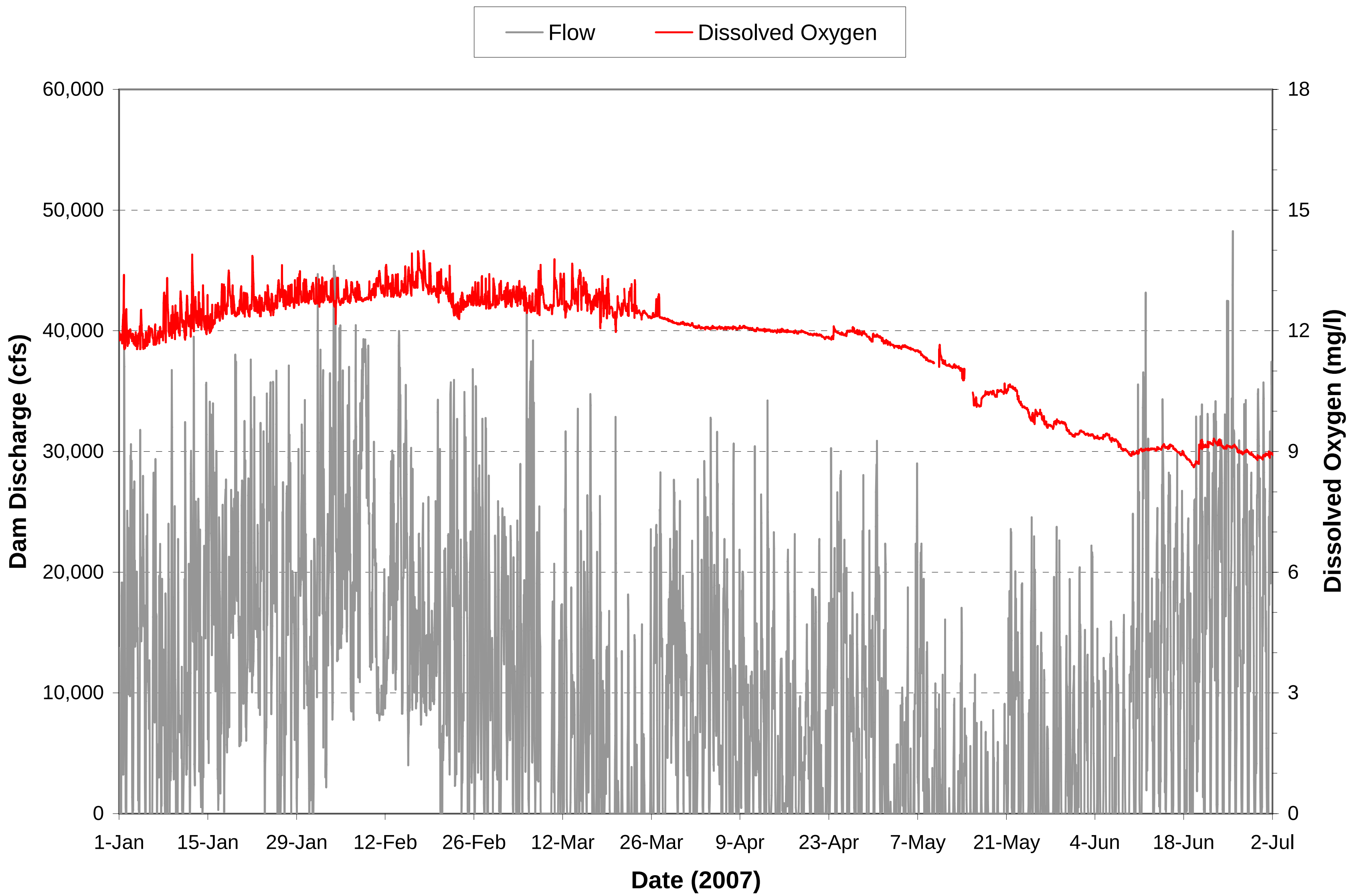


Plate 171. Hourly discharge and dissolved oxygen monitored at the Oahe powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

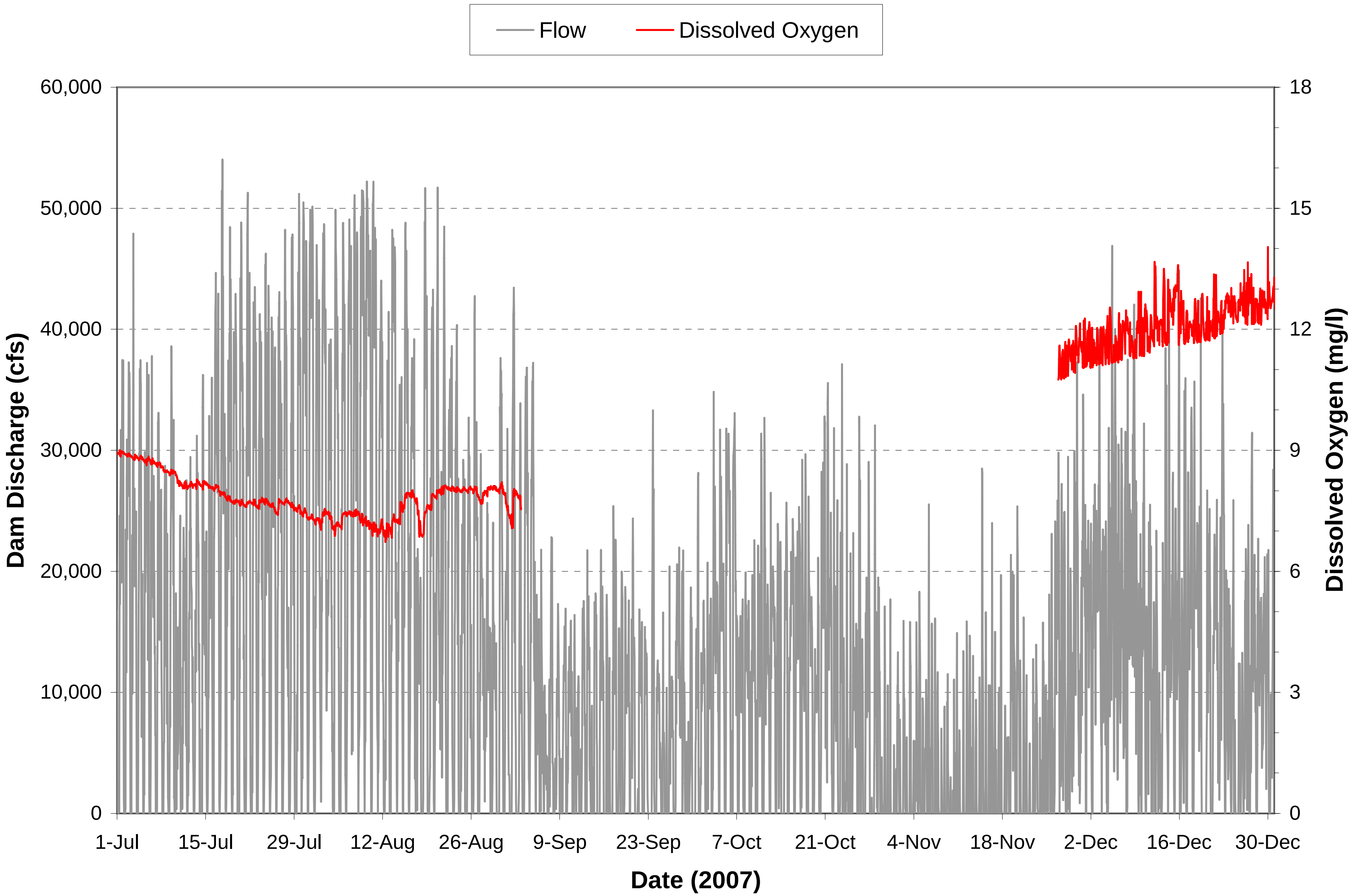


Plate 172. Hourly discharge and dissolved oxygen monitored at the Oahe Powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

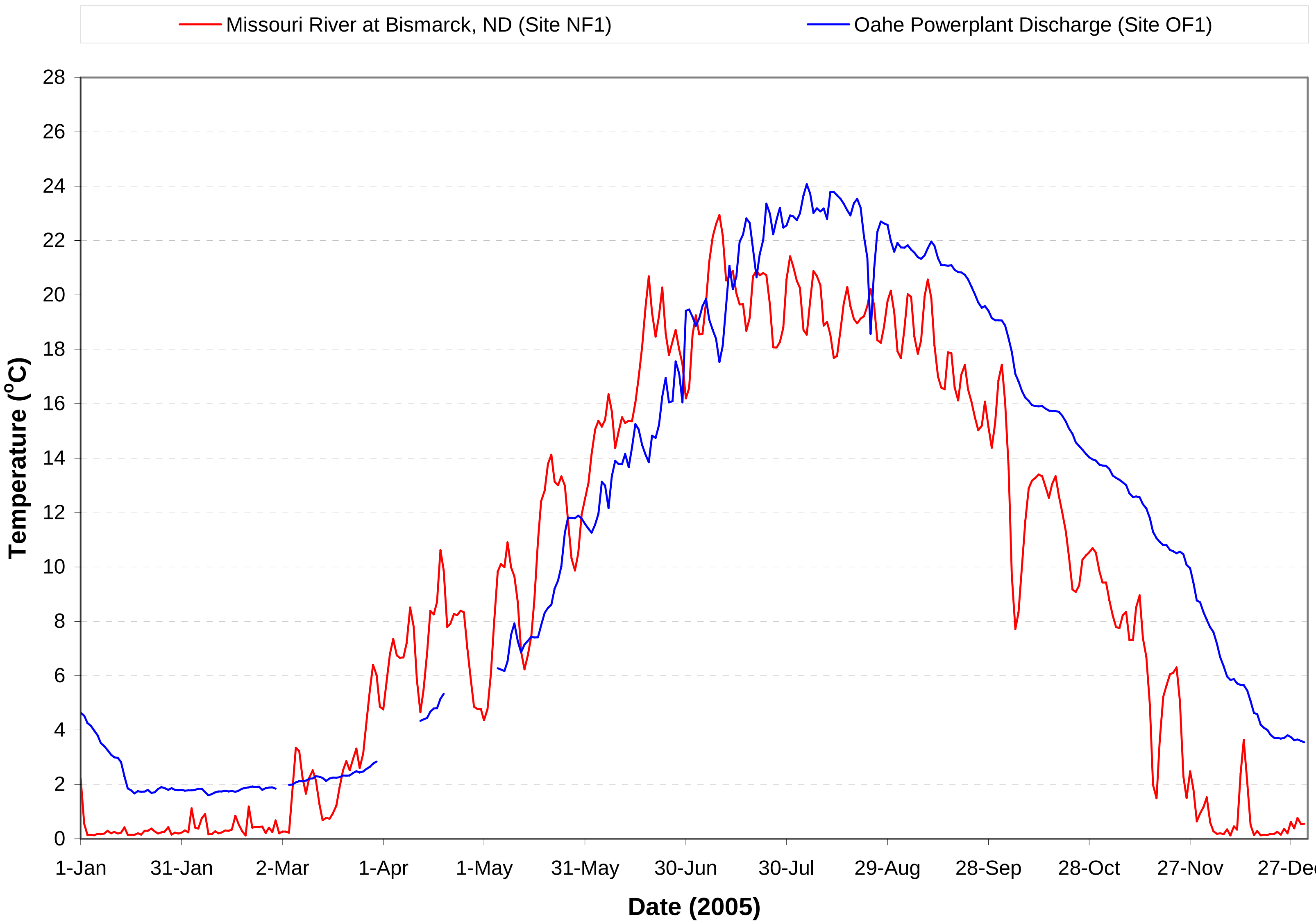


Plate 173. Mean daily water temperatures monitored at the Oahe Powerplant (i.e., site OAHPP1) and the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) during 2005. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

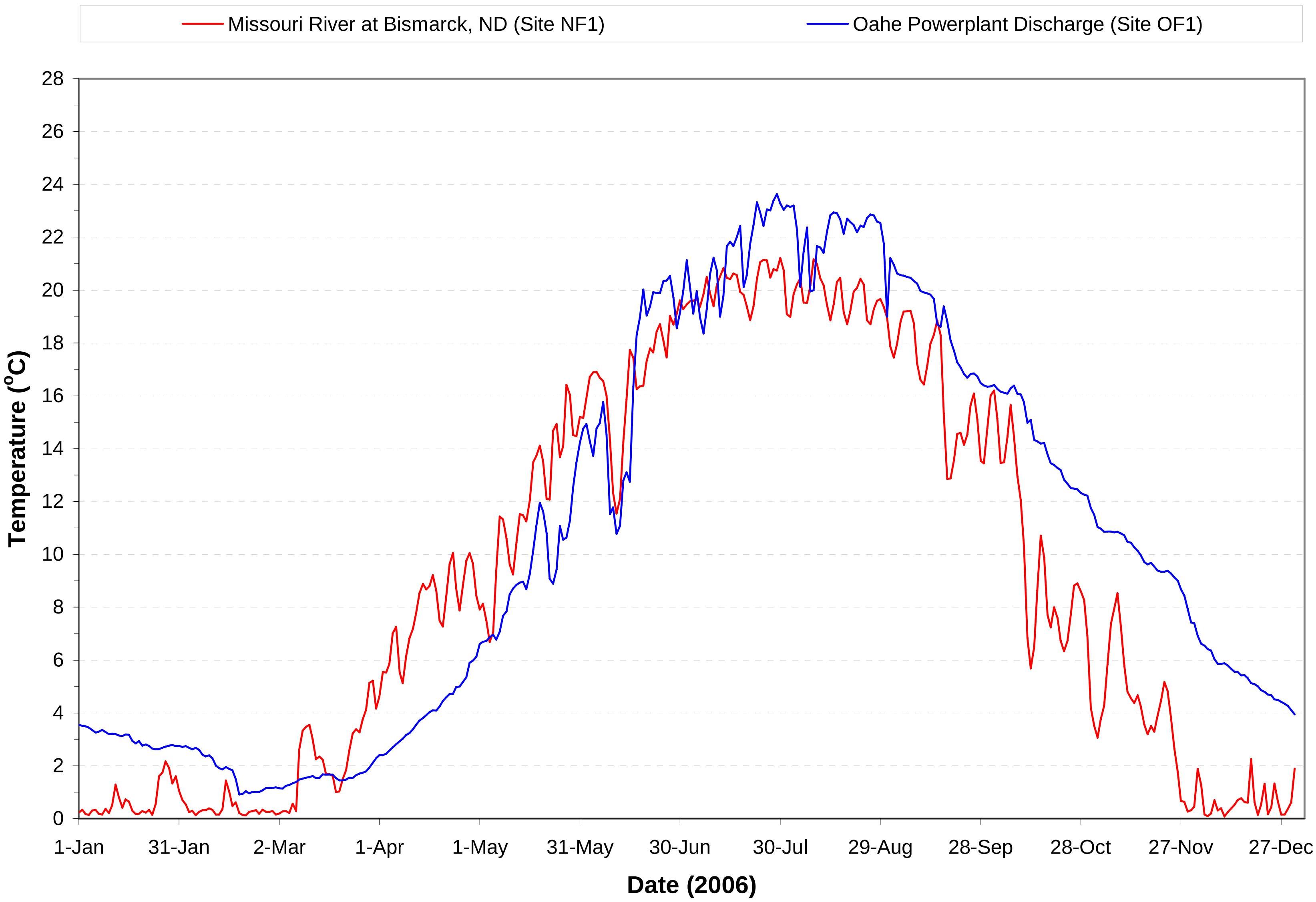


Plate 174. Mean daily water temperatures monitored at the Oahe Powerplant (i.e., site OAHPP1) and the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) during 2006.

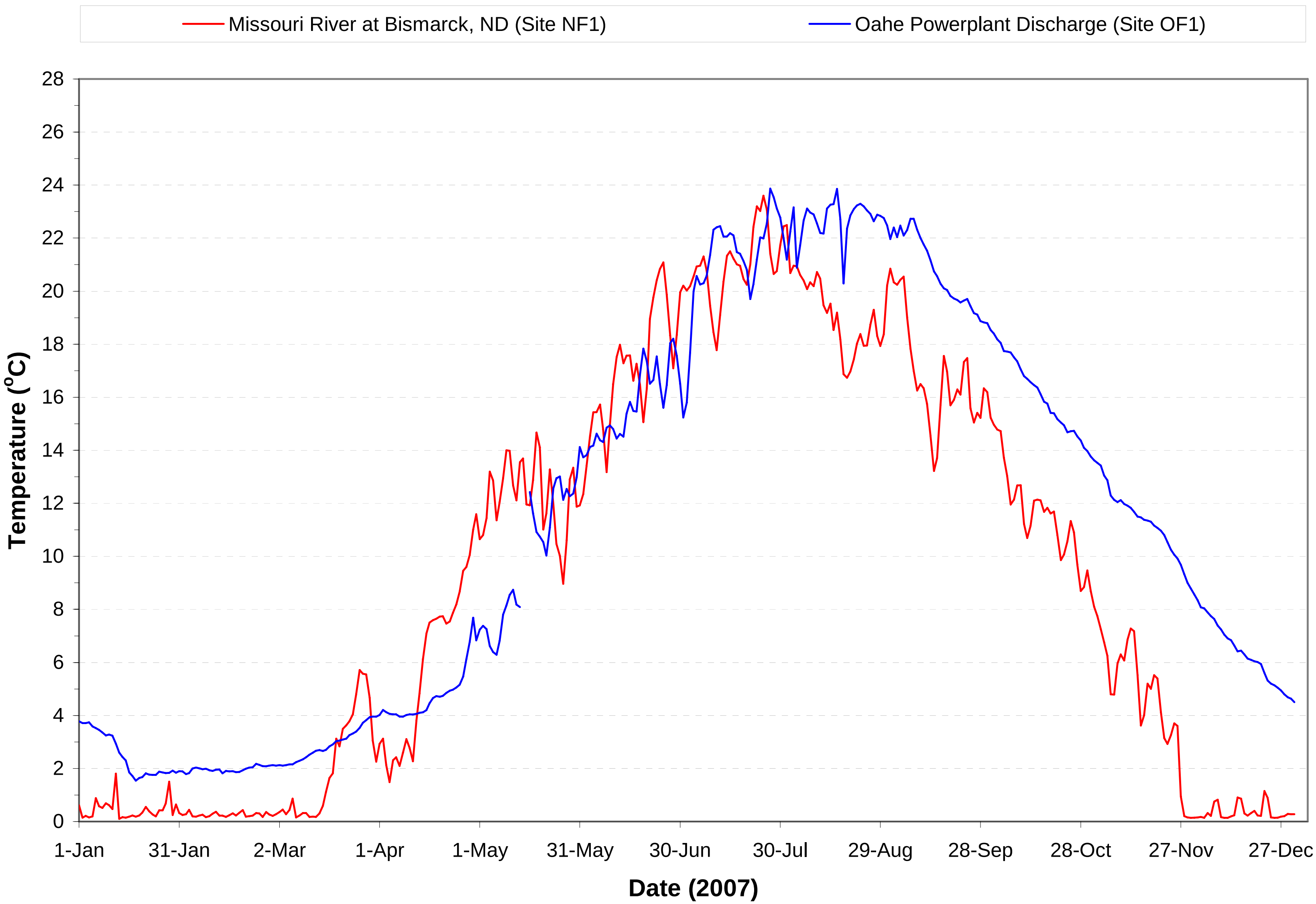


Plate 175. Mean daily water temperatures monitored at the Oahe Powerplant (i.e., site OAHPP1) and the Missouri River near Bismarck, North Dakota (i.e., site OAHNFMORR1) during 2007.

Plate 176. Summary of monthly (May through September) water quality conditions monitored in Big Bend Reservoir near Big Bend Dam (Site BBDLK0987A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	25	1420.4	1420.3	1420.0	1420.9	-----	-----	-----
Water Temperature (C)	0.1	563	19.6	20.3	10.3	27.3	18.3[1] 23.9[1] 27.0[1]	370 124 3	66% 22% <1%
Dissolved Oxygen (mg/l)	0.1	563	8.0	7.9	3.1	10.3	7.0[2] 6.0[2] 5.0[2]	108 25 5	19% 4% <1%
Dissolved Oxygen (% Sat.)	0.1	563	90.4	92.2	37.3	107.7	----	-----	-----
Specific Conductance (umho/cm)	1	562	687	704	546	796	-----	-----	-----
pH (S.U.)	0.1	540	8.4	8.4	7.8	9.0	6.6[3] 8.6[3] 9.0[3]	0 145 0	0% 27% 0%
Turbidity (NTUs)	0.1	538	5.8	4.6	n.d.	38.4	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	496	357	365	259	441	-----	-----	-----
Secchi Depth (in.)	1	24	84	75	40	196	-----	-----	-----
Alkalinity, Total (mg/l)	7	48	170	170	140	198	-----	-----	-----
Ammonia, Total (mg/l)	0.01	48	-----	0.05	n.d.	0.48	2.59 [4,5], 0.84 [4,6]	0	0%
Carbon, Total Organic (mg/l)	0.05	46	3.1	3.1	1.5	4.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	22	10	10	n.d.	20	-----	-----	-----
Chloride (mg/l)	1	22	10	10	9	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	449	-----	1	n.d.	14	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	22	-----	2	n.d.	4	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	24	479	475	444	560	1,750[7]	0	0%
Iron, Dissolved (ug/l)	40	15	-----	n.d.	n.d.	20	-----	-----	-----
Iron, Total (ug/l)	40	15	109	100	n.d.	229	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	48	0.3	0.3	n.d.	0.8	-----	-----	-----
Manganese, (Dissolved) (ug/l)	1	15	-----	2	n.d.	14	-----	-----	-----
Manganese, Total (ug/l)	1	15	27	30	4	61	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	48	-----	n.d.	n.d.	0.11	10[7]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	18	-----	n.d.	n.d.	0.18	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	48	0.05	0.03	n.d.	0.47	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	48	-----	n.d.	n.d.	0.16	-----	-----	-----
Sulfate (mg/l)	1	24	206	210	165	230	875[7]	0	0%
Suspended Solids, Total (mg/l)	4	48	-----	n.d.	n.d.	7	53[5], 30[6]	0	0%
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The State temperature criterion for protection of coldwater permanent fish life propagation, which is a designated use of Big Bend Reservoir, is 18.3 C. For reference, the defined State criterion for protection of coldwater marginal fish life propagation is 23 9 C, and for the protection of warmwater permanent fish life propagation is 27.0 C.

(2) Minimum dissolved oxygen criteria for the protection of coldwater permanent fish life propagation. The 7.0 mg/l criterion applies to spawning areas during spawning season, and the 6.0 mg/l criterion applies otherwise. For reference, the minimum dissolved oxygen criterion for the protection of warmwater permanent fish life propagation is 5.0 mg/l.

(3) The pH criteria of 6.6 and 8.6 are, respectively, minimum and maximum criteria for the protection of coldwater permanent fish life propagation. For reference, the maximum criterion for the protection of warmwater permanent fish life propagation is 9.0 SU.

(4) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.

(5) Acute criterion for aquatic life.

(6) Chronic criterion for aquatic life.

(7) Daily maximum criterion for domestic water supply.

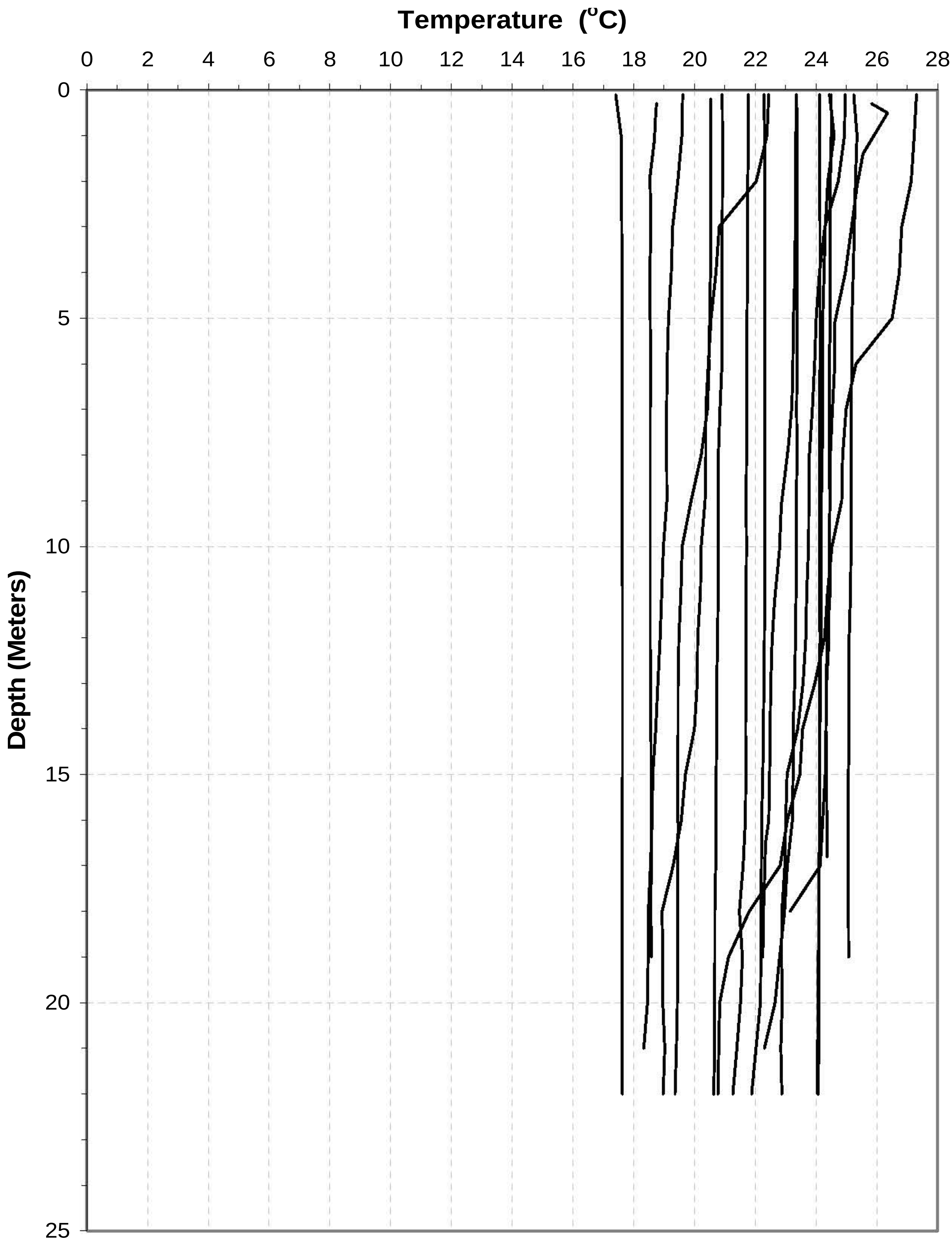


Plate 177. Temperature depth profiles for Big Bend Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site during the summer months of the 5-year period of 2003 to 2007.

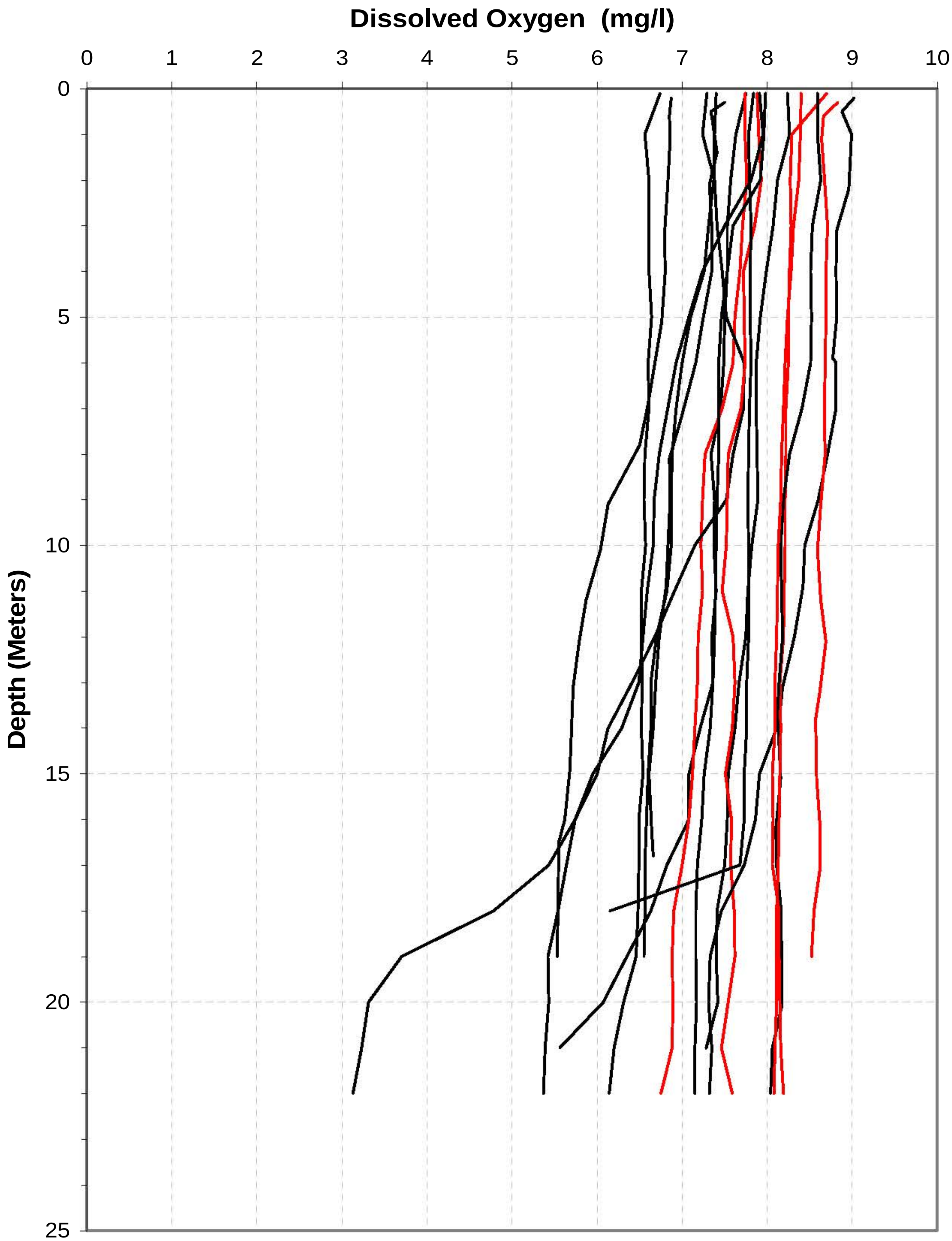


Plate 178. Dissolved oxygen depth profiles for Big Bend Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site during the summer months of the 5-year period of 2003 through 2007. (Note: Red profile plots were measured in the month of September.)

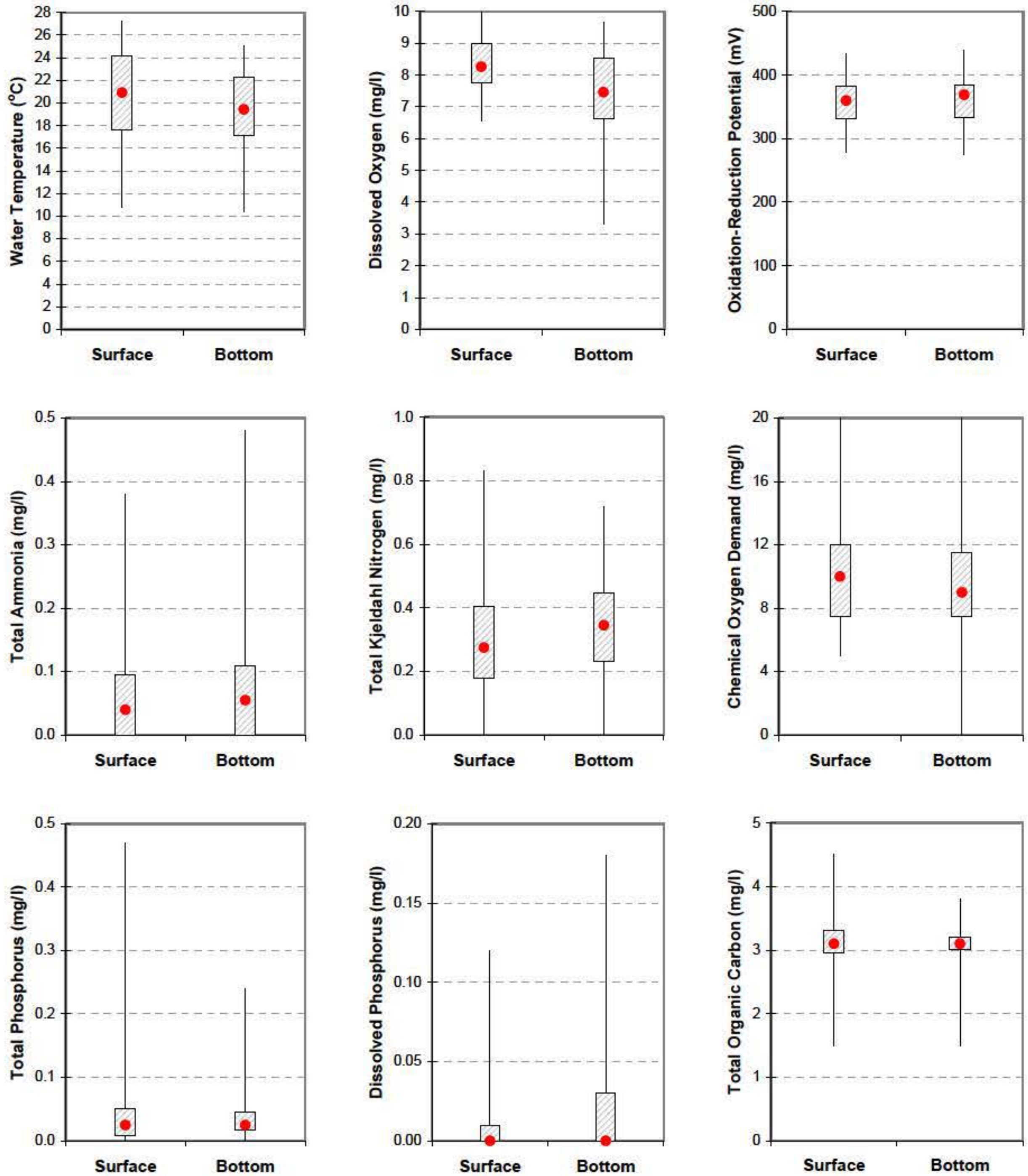


Plate 179. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measured in Big Bend Reservoir at site BBDLK0987A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 180. Total biovolume, number of genera present and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected at the near-dam, deepwater ambient monitoring site (i.e., site BBDLK0987A) at Big Bend Reservoir during the period 2004 through 2006.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	6,563,514	3	0.77	0	-----	0	-----	2	0.20	2	0.04	0	-----	0	-----	1.24
Jul 2004	6,337,657	1	0.77	0	-----	0	-----	1	0.03	4	0.20	0	-----	0	-----	0.70
Aug 2004	129,629,728	7	0.79	5	0.05	0	-----	1	0.02	3	<0.01	2	0.13	0	-----	1.15
May 2005	400,458,770	6	0.93	3	<0.01	0	-----	1	0.07	1	<0.01	0	-----	0	-----	1.47
Jun 2005	12,306,159	2	0 26	1	0.04	0	-----	2	0.63	4	0.07	0	-----	0	-----	1.58
Jul 2005	223,854,976	11	0 97	2	0.01	0	-----	0	-----	1	0.01	0	-----	0	-----	1.55
Aug 2005	111,016,029	5	0.22	0	-----	2	0.26	1	0.03	8	0.48	0	-----	0	-----	2.03
Sep 2005	290,622,396	8	0.77	14	0.06	0	-----	1	0.04	5	0.12	2	<0.01	1	<0.01	1.80
May 2006	782,608,177	7	0.97	2	<0.01	0	-----	1	<0.01	0	-----	0	-----	1	0.03	0 93
Jun 2006	569,715,640	7	0.98	8	<0.01	1	<0.01	1	0.02	0	-----	0	-----	0	-----	0.16
Jul 2006	71,040,754	5	0 13	9	0.41	1	<0.01	1	0.16	3	0.14	1	0.16	0	-----	2.33
Aug 2006	460,223,040	13	0.71	14	0.15	1	0.01	1	0.01	5	0.06	3	0.06	1	0.01	2.37
Sep 2006	112,017,227	10	0.51	16	0.25	1	<0.01	1	0.05	7	0.09	2	0.09	1	<0.01	2.68
May 2007	569,470,258	9	0.95	5	0.01	0	-----	1	0.02	1	<0.01	1	0.02	0	-----	0.61
June 2007	517,899,330	5	0.74	9	0.10	1	0.13	1	0.02	1	0.01	0	-----	0	-----	1.00
July 2007	211,432,753	7	0.17	8	0.06	0	-----	2	0.13	4	0.26	1	0.38	0	-----	1.85
Aug 2007	269,806,875	10	0.20	11	0.22	1	0.03	1	0.04	4	0.42	2	0.10	0	----	2.12
Sep 2007	141,864,320	6	0.34	12	0.25	0	-----	1	0.18	7	0.15	1	0.07	0	-----	2.74
Mean	**271,492,645**	**6.78**	**0.62**	**6.61**	**0.11**	**0.44**	**0.06**	**1.11**	**0.10**	**3.33**	**0.13**	**0 83**	**0.11**	**0.22**	**0.01**	**1.57**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 181. Dominant taxa present in phytoplankton grab samples collected at the near-dam monitoring site (site BBDLK0987A) at Big Bend Reservoir during the period 2004 through 2006.

Date	Division	Dominant Taxa*	Percent of Total Biovolume
June 2004	Bacillariophyta	*Asterionella formossa*	0.61
	Bacillariophyta	*Navicula spp.*	0.14
	Cryptophyta	*Rhodomonas minuta*	0.13
July 2004	Bacillariophyta	*Asterionella formossa*	0.77
	Cyanobacteria	*Anabaena spp.*	0.13
August 2004	Bacillariophyta	*Fragilaria crotonensis*	0.70
	Pyrrophyta	*Ceratium hirundinella*	0.13
May 2005	Bacillariophyta	*Fragilaria crotonensis*	0.36
	Bacillariophyta	*Tabellaria fenestrata*	0.29
	Bacillariophyta	*Asterionella formossa*	0.23
June 2005	Cryptophyta	*Rhodomonas minuta*	0.37
	Cryptophyta	*Cryptomonas spp.*	0.26
	Bacillariophyta	*Stephanodiscus spp.*	0.22
July 2005	Bacillariophyta	*Fragilaria crotonensis*	0.45
	Bacillariophyta	*Asterionella formossa*	0.31
August 2005	Cyanobacteria	*Pseudanabaena limnetica*	0.33
	Chrysophyta	*Dinobryon sertularia*	0.24
September 2005	Bacillariophyta	*Stephanodiscus hantzschii*	0.56
May 2006	Bacillariophyta	*Asterionella formossa*	0.48
	Bacillariophyta	*Fragilaria crotonensis*	0.45
June 2006	Bacillariophyta	*Fragilaria spp.*	0.97
July 2006	Pyrrophyta	*Ceratium hirundinella*	0.16
	Cryptophyta	*Rhodomonas minuta*	0.16
	Chlorophyta	*Cosmarium spp.*	0.16
	Cyanobacteria	*Gomphosphaeria aponina*	0.13
August 2006	Bacillariophyta	*Stephanodiscus hantzschii*	0.41
September 2006	Bacillariophyta	*Cyclotella spp.*	0.31
May 2007	Bacillariophyta	*Fragilaria spp.*	0.87
June 2007	Bacillariophyta	*Fragilaria spp.*	0.73
	Chrysophyta	*Dinobryon spp.*	0.13
July 2007	Pyrrophyta	*Ceratium hirundinella*	0.38
	Cyanobacteria	*Anabaena spp.*	0.25
	Cryptophyta	*Rhodomonas spp.*	0.12
August 2007	Cyanobacteria	*Dactylococcopsis acicularis*	0.41
	Chlorophyta	*Pediastrum duplex var. clathratum*	0.16
September 2007	Cryptophyta	*Rhodomonas spp.*	0.18
	Bacillariophyta	*Fragilaria spp.*	0.11

* Dominant taxa are genera or species (depending on identification level) that comprised more than 10% of the total sample biovolume.

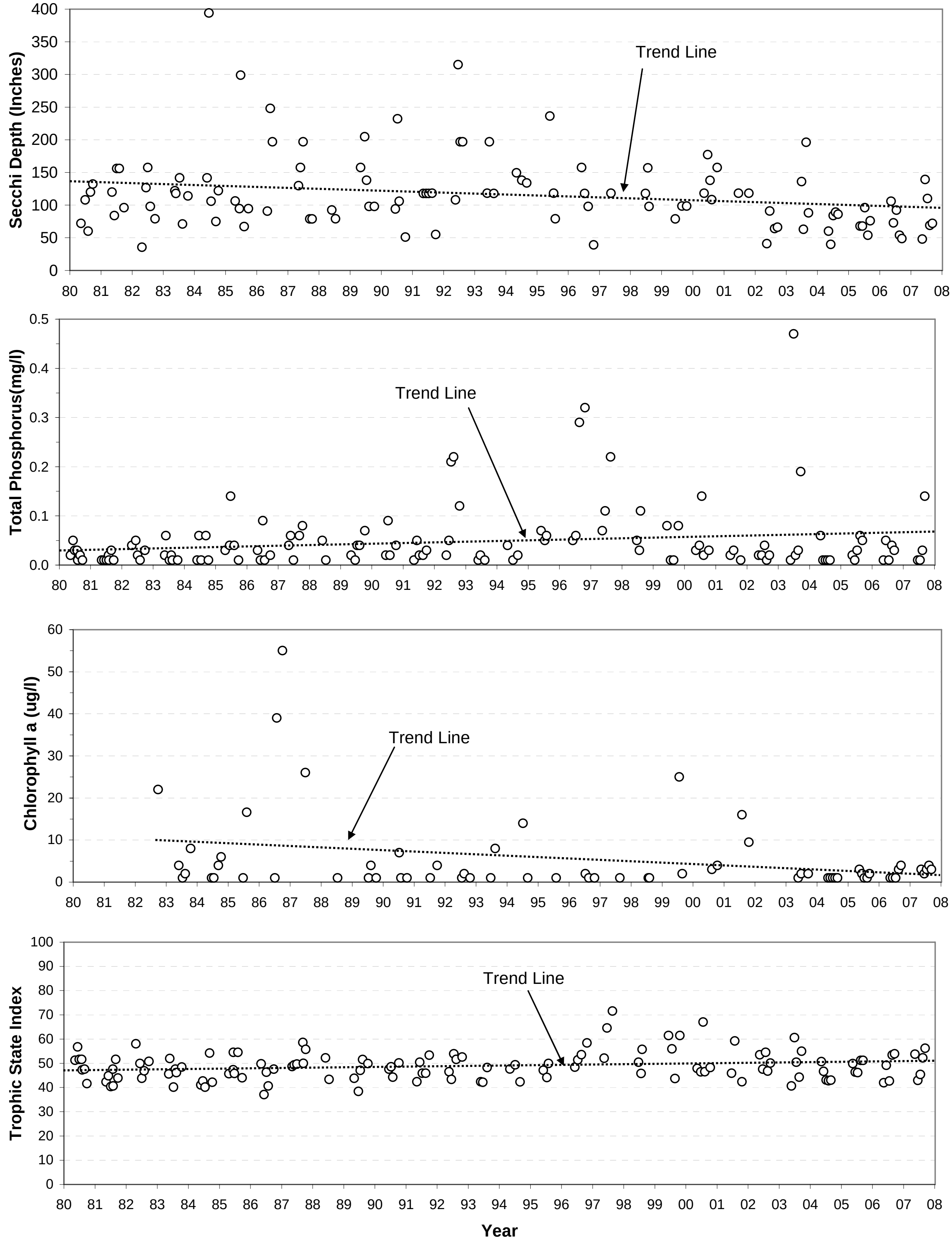


Plate 182. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Big Bend Reservoir at the near-dam, ambient site (i.e., site BBDLK0987A) over the 28-year period of 1980 to 2007.

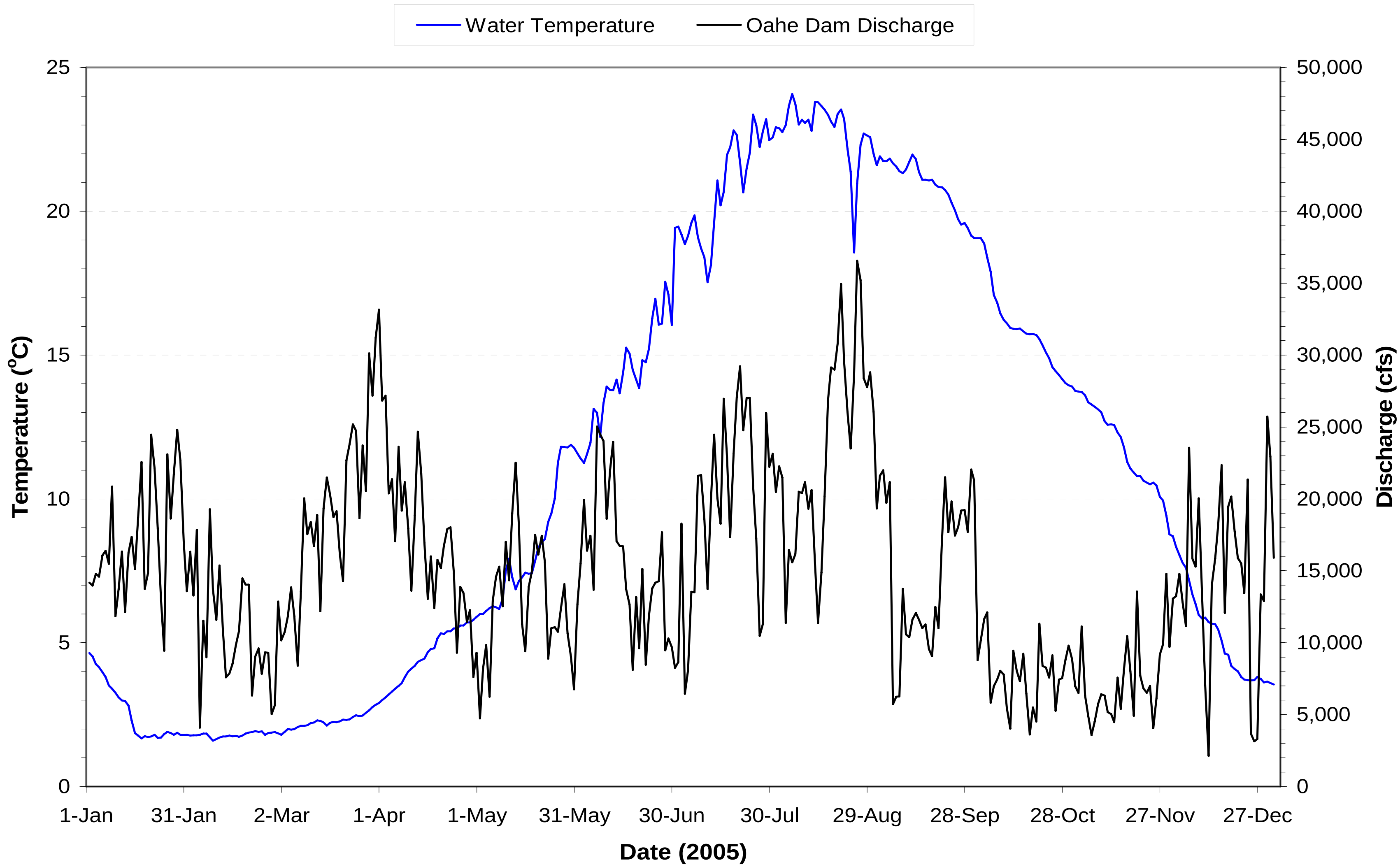


Plate 183. Mean daily water temperature and discharge of the Missouri River at Oahe Dam (i.e., site OAHPP1) for 2005. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Oahe Dam.

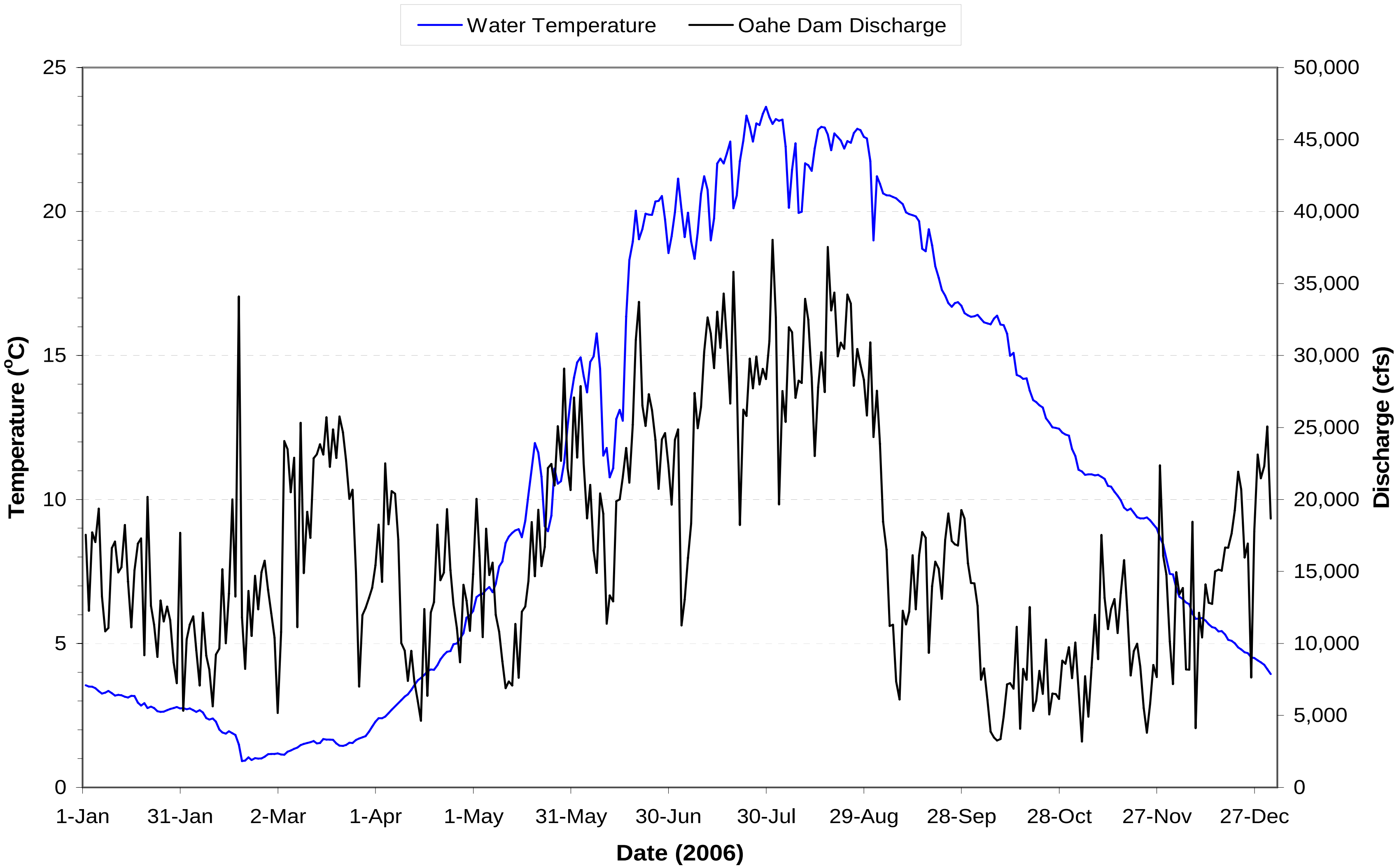


Plate 184. Mean daily water temperature and discharge of the Missouri River at Oahe Dam (i.e., site OAHPP1) for 2006. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Oahe Dam.

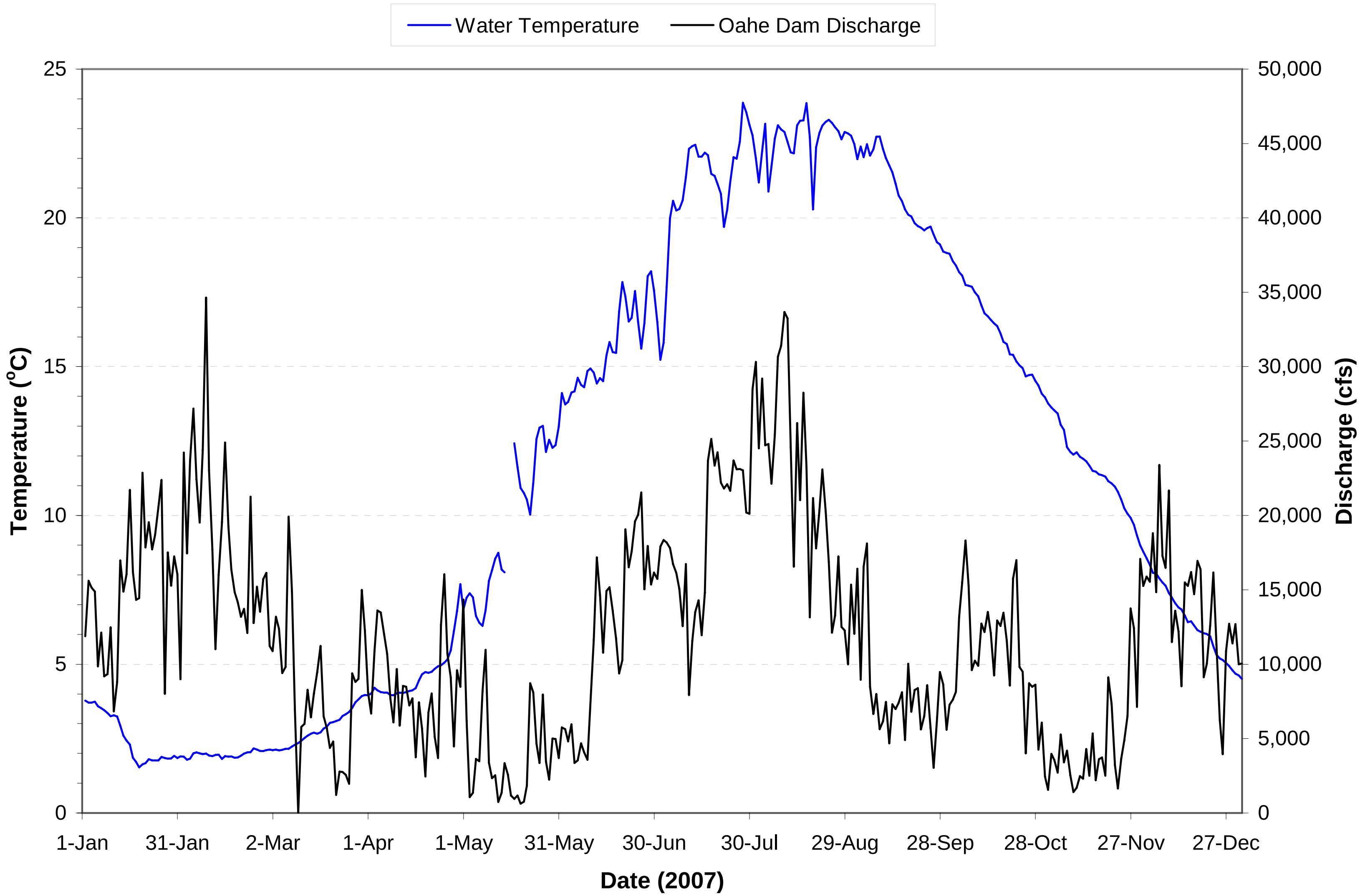


Plate 185. Mean daily water temperature and discharge of the Missouri River at Oahe Dam (i.e., site OAHPP1) for 2007. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Oahe Dam.

Plate 186. Summary of water quality conditions monitored on water discharged through Big Bend Dam (i.e., site BBDPP1) during the 4-year period of 2004 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	37	25,067	23,200	0	71,980	-----	-----	-----
Water Temperature (C)	0.1	33	13.4	13.4	1.4	25.4	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	33	9.2	9.1	3.8	13.5	≥ 5.0	1	3%
Dissolved Oxygen (% Sat.)	0.1	33	88.3	90.3	44.7	105.5	-----	-----	-----
Specific Conductance (umho/cm)	1	33	668	682	500	739	-----	-----	-----
pH (S.U.)	0.1	33	8.3	8.3	7.6	8.7	≥6.5 & ≤9.0	1	<1%
Oxidation-Reduction Potential	1	16	416	407	243	641	-----	-----	-----
Alkalinity, Total (mg/l)	7	37	173	170	140	206	-----	-----	-----
Ammonia, Total (mg/l)	0.01	37	-----	0.04	n.d.	0.31	3.15 [(1,2)], 1.44 [(1,3)]	0	0%
Carbon, Total Organic (mg/l)	0.05	36	3.1	3.1	1.5	5.3	-----	-----	-----
Chloride (mg/l)	1	19	11	11	9	13	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	10	10	5	21	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	37	476	470	379	753	1,750[(4)]	0	0%
Hardness, Total (mg/l)	0.4	2	224	224	220	228	-----	-----	-----
Iron, Dissolved (ug/l)	40	27	-----	n.d.	n.d.	142	-----	-----	-----
Iron, Total (ug/l)	40	29	222	157	n.d.	688	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	37	0.5	0.3	n.d.	1.7	-----	-----	-----
Manganese, Dissolved (ug/l)	1	27	5	3	n.d.	53	-----	-----	-----
Manganese, Total (ug/l)	1	29	55	42	n.d.	178	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	37	-----	n.d.	n.d.	0.30	10[(4)]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	19	-----	n.d.	n.d.	0.07	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	37	-----	0.02	n.d.	0.30	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	35	-----	n.d.	n.d.	0.02	-----	-----	-----
Sulfate (mg/l)	1	37	201	202	119	230	875[(4)]	0	0%
Suspended Solids, Total (mg/l)	4	37	-----	n.d.	n.d.	20	158[(2)], 90[(3)]	0	0%
Antimony, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	0.6	6[(4)]	0	0%
Arsenic, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	1	340[(2)], 150[(3)], 50[(4)]	0	0%
Barium, Dissolved (ug/l)	5	1	44	44	44	44	1,000[(4)]	0	0%
Beryllium, Dissolved (ug/l)	2	3	-----	n.d.	n.d.	n.d.	4[(4)]	0	0%
Cadmium, Dissolved (ug/l)	0.2	6	-----	n.d.	n.d.	n.d.	11.2[(2)], 4.6[(3)], 5[(4)]	0	0%
Chromium, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	3,490[(2)], 167[(3)], 100[(4)]	0	0%
Copper, Dissolved (ug/l)	2	6	-----	n.d.	n.d.	n.d.	29.9[(2)], 18.6[(3)], 1,000[(4)]	0	0%
Lead, Dissolved (ug/l)	0.5	6	-----	n.d.	n.d.	n.d.	228[(2)], 8.9[(3)], 15[(4)]	0	0%
Mercury, Dissolved (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	-----	-----	-----
Mercury, Total (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	1.7[(2)], 0.91[(3)], 0.05[(4)]	0	0%
Nickel, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	928[(2)], 103[(3)], 100[(4)]	0	0%
Selenium, Total (ug/l)	1	5	-----	n.d.	n.d.	1	20[(2)], 5[(3)], 50[(4)]	0	0%
Silver, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	n.d.	14.7	0	0%
Thallium, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	n.d.	0.47[(4)]	0	0%
Zinc, Dissolved (ug/l)	10	6	8	10	n.d.	11	237[(2,3)], 9,100[(4)]	0	0%
Pesticide Scan (ug/l)***	0.05	4	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** [(1)] Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
[(2)] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
[(3)] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
[(4)] Human health criterion for surface waters.
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness of 224 mg/l.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

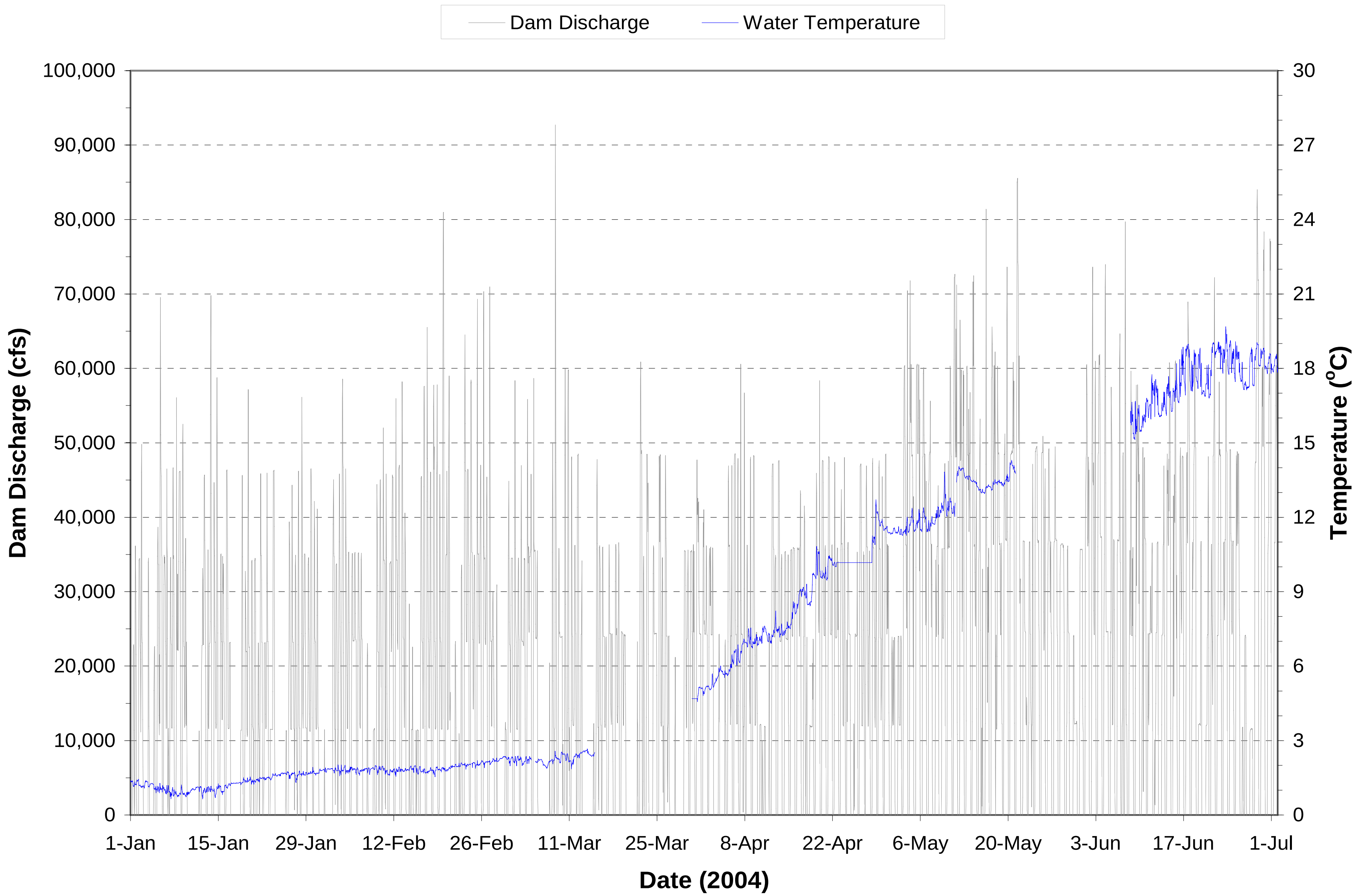


Plate 187. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

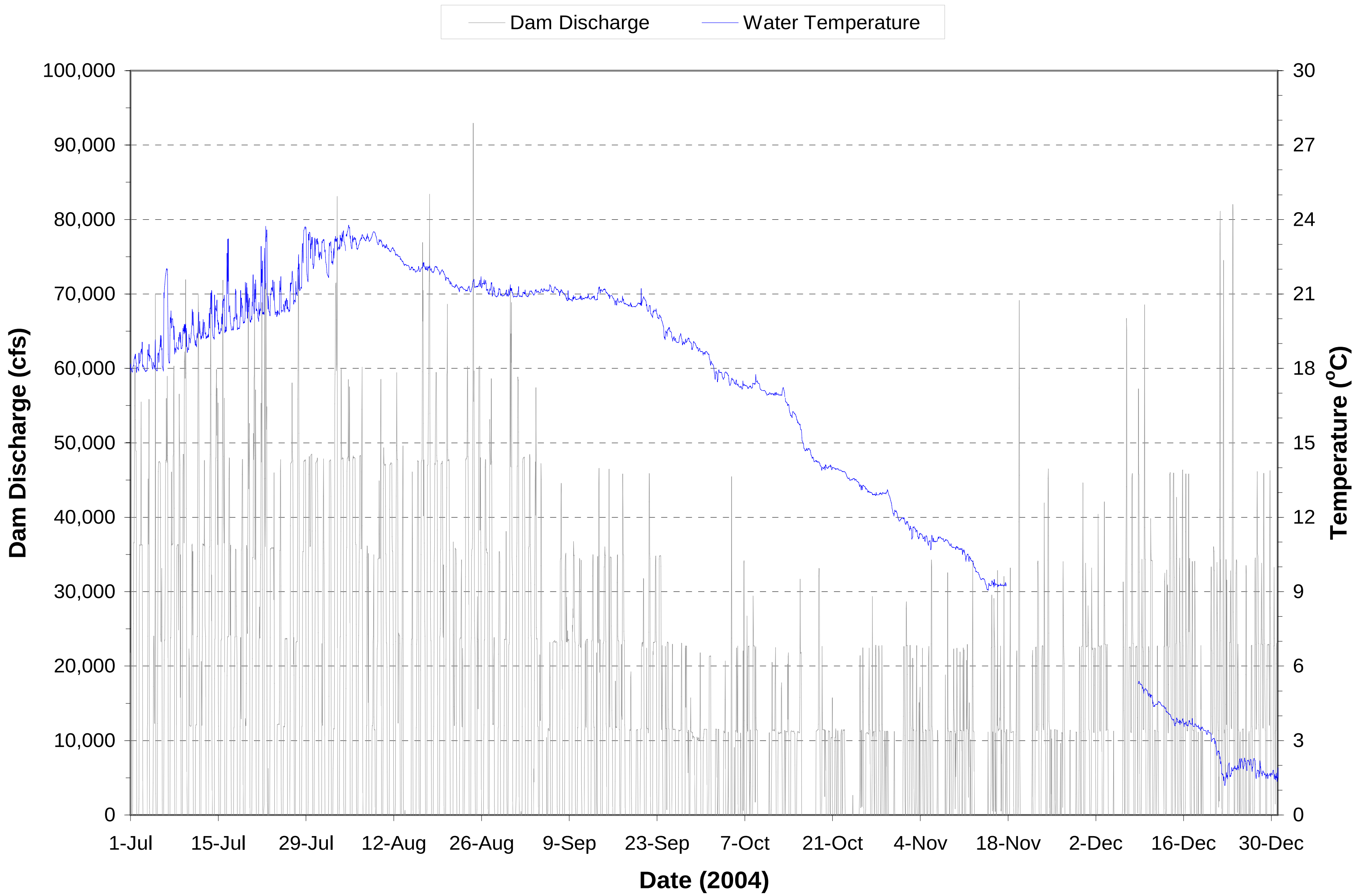


Plate 188. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

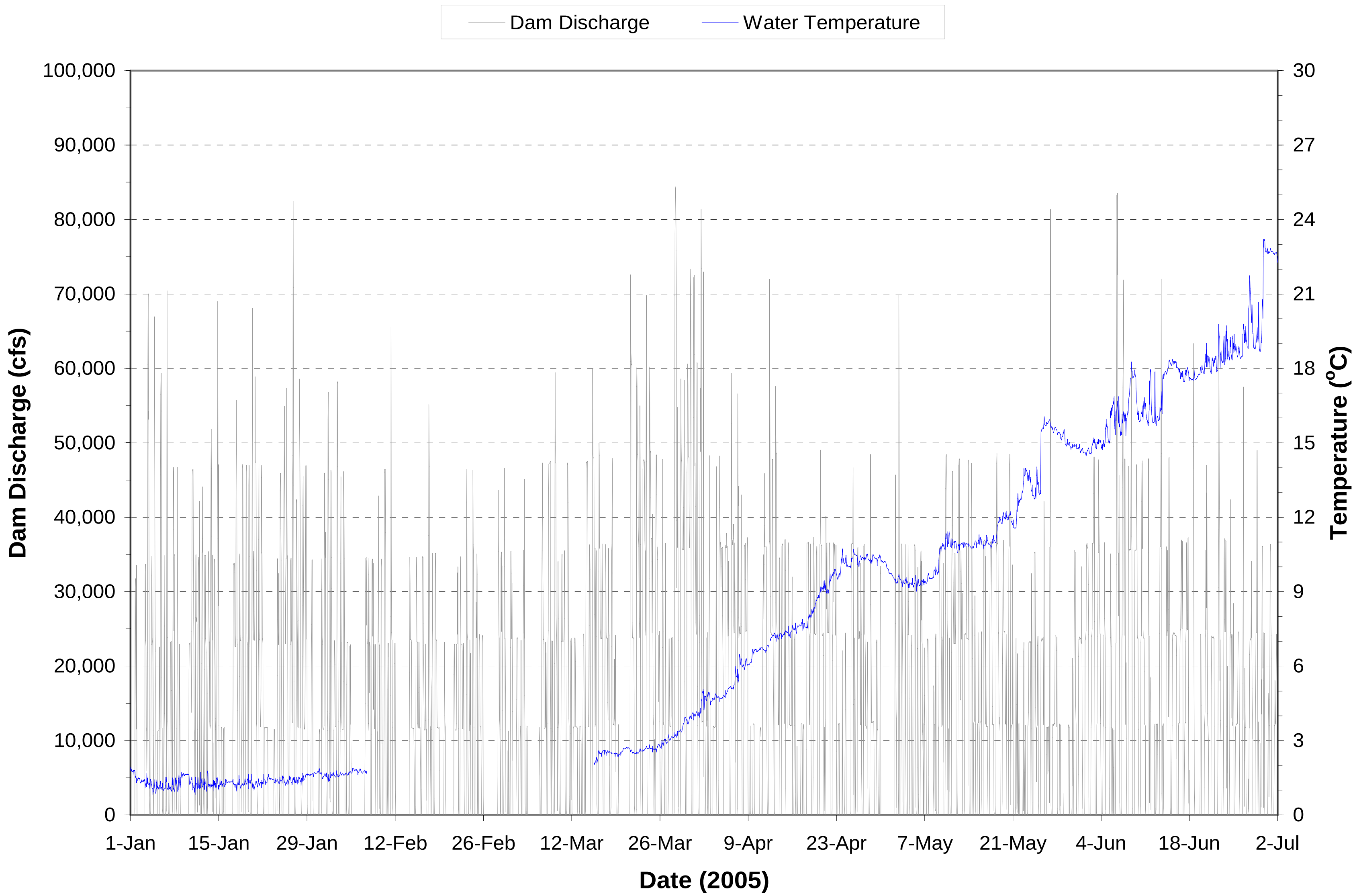


Plate 189. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

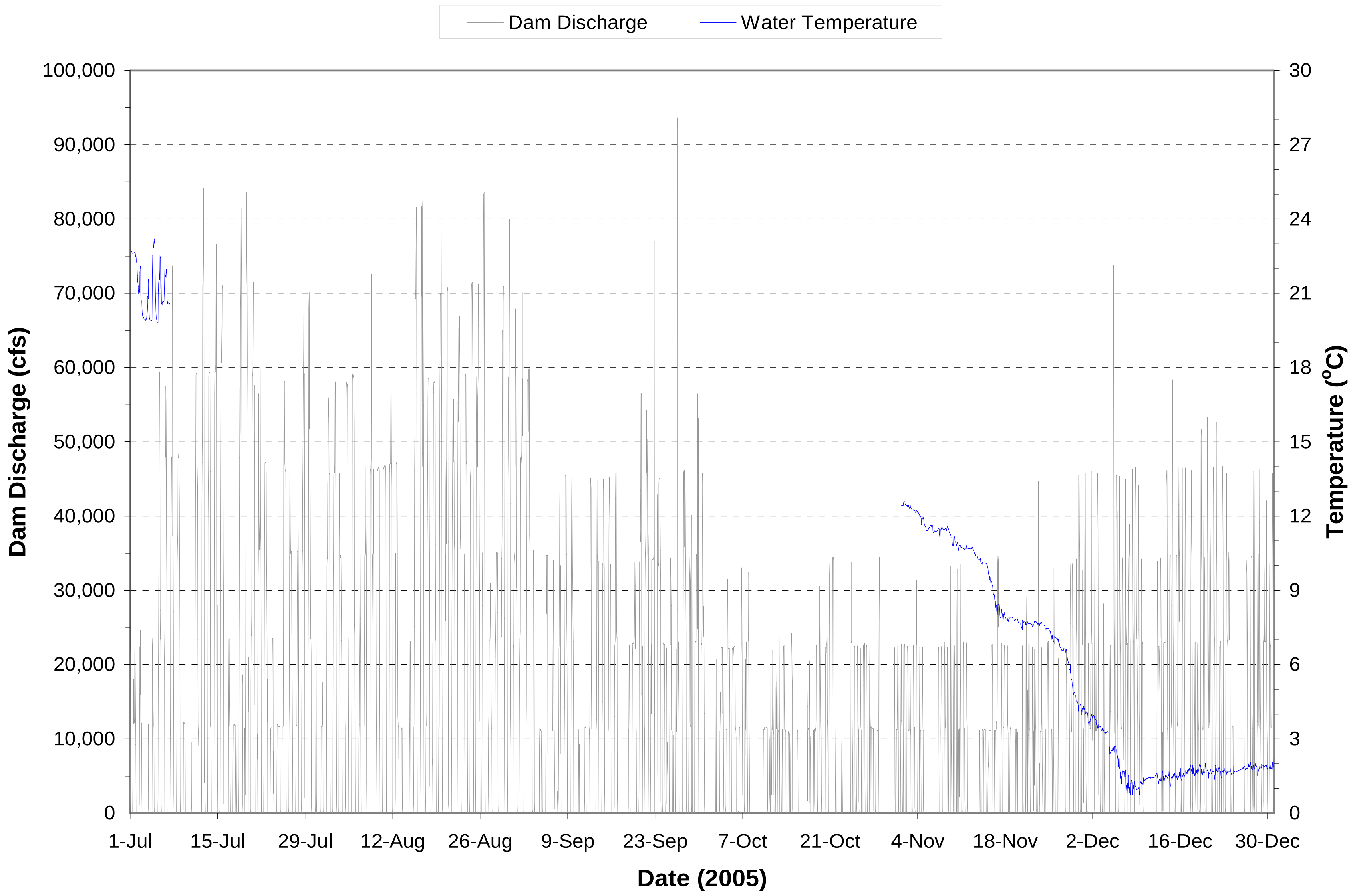


Plate 190. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

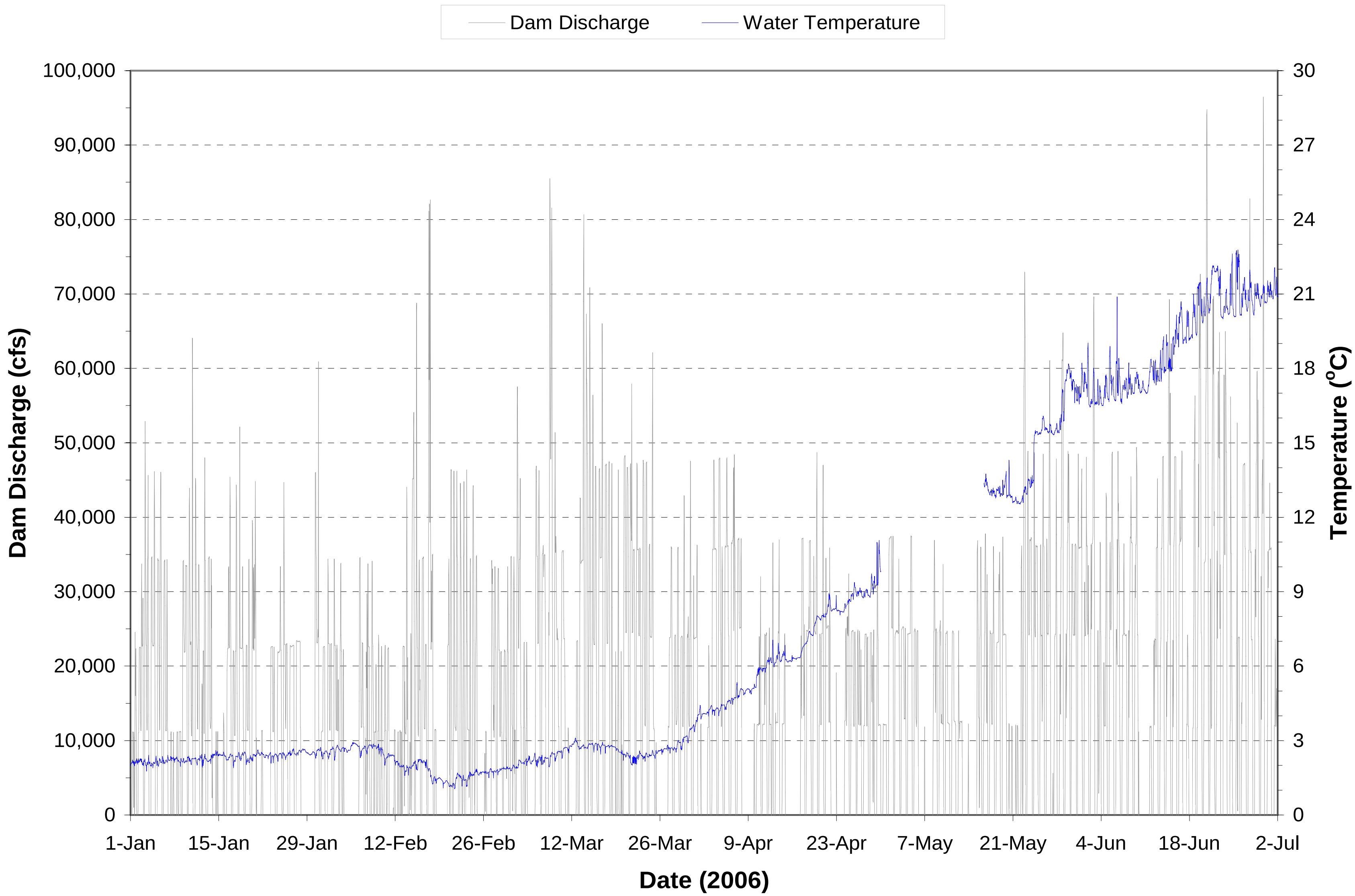


Plate 191. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

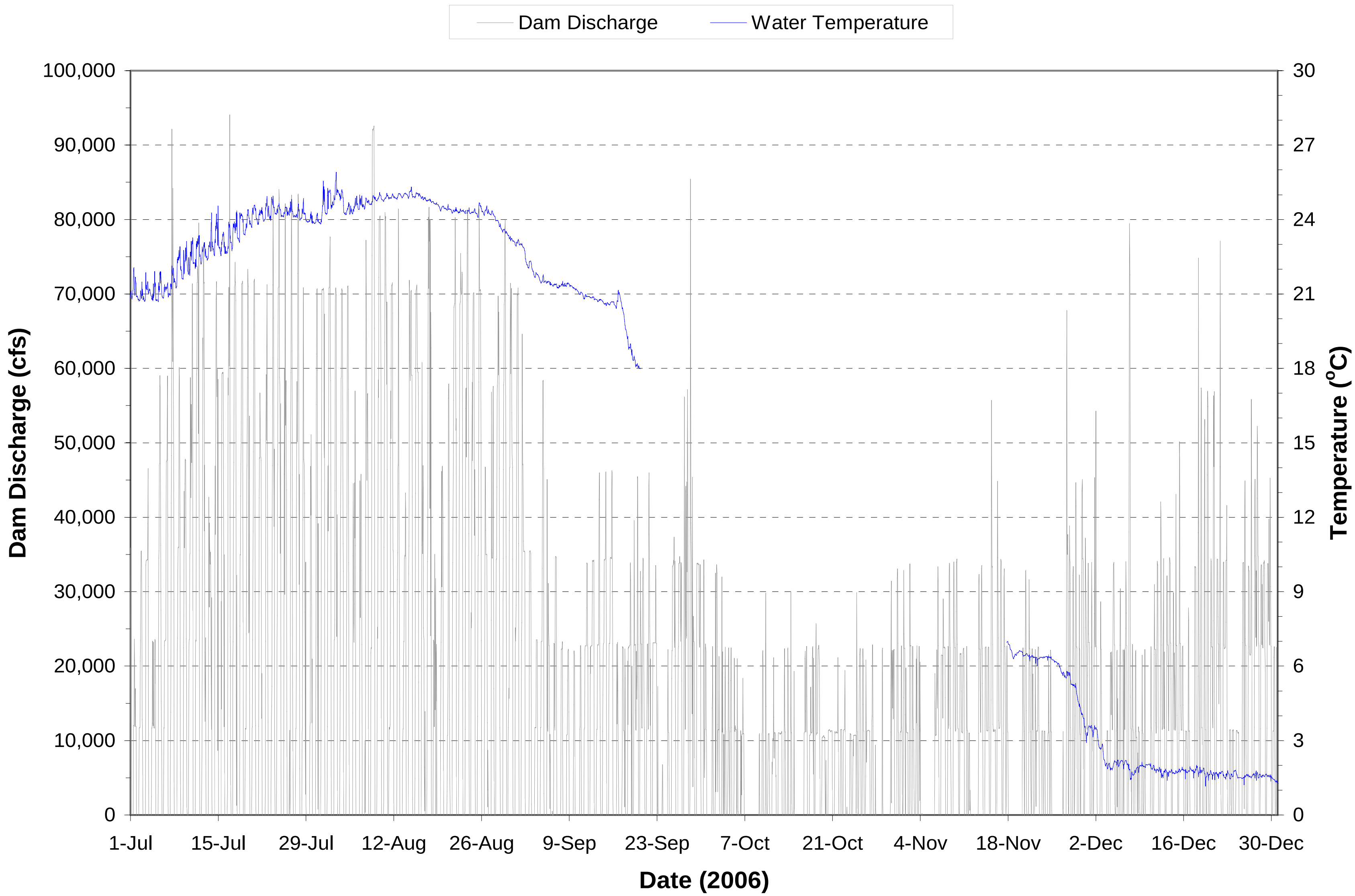


Plate 192. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

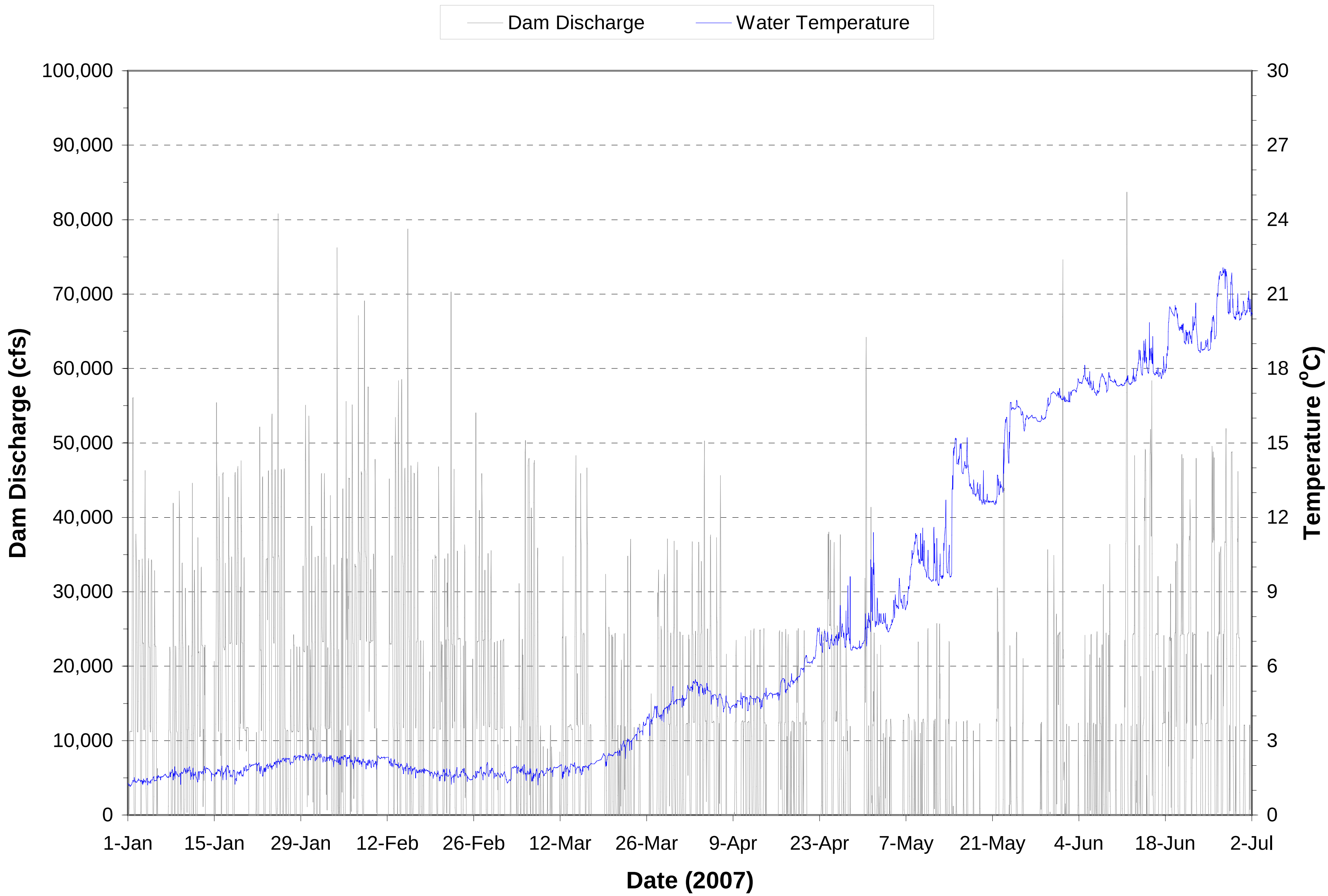


Plate 193. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2007.

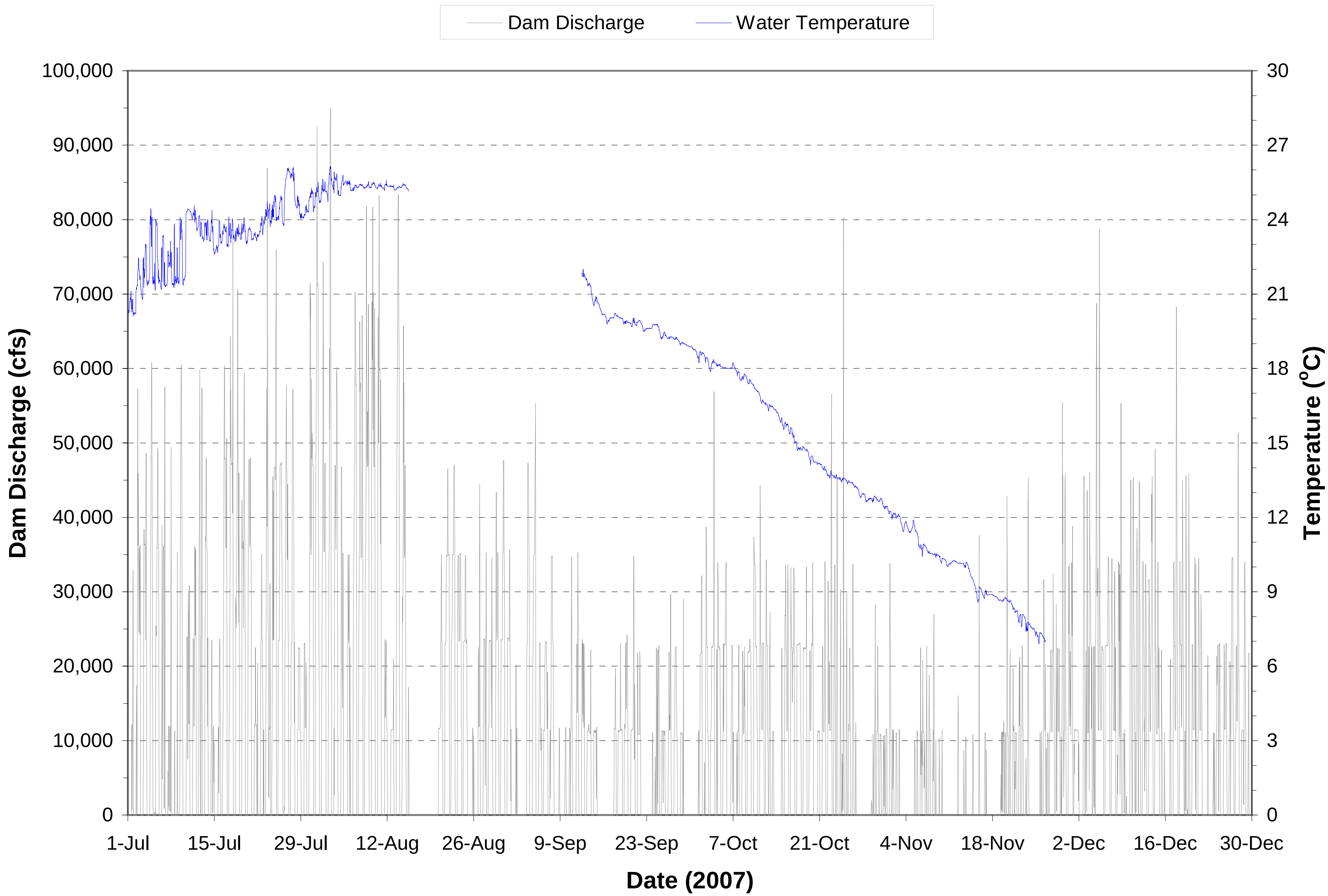


Plate 194. Hourly discharge and water temperature monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

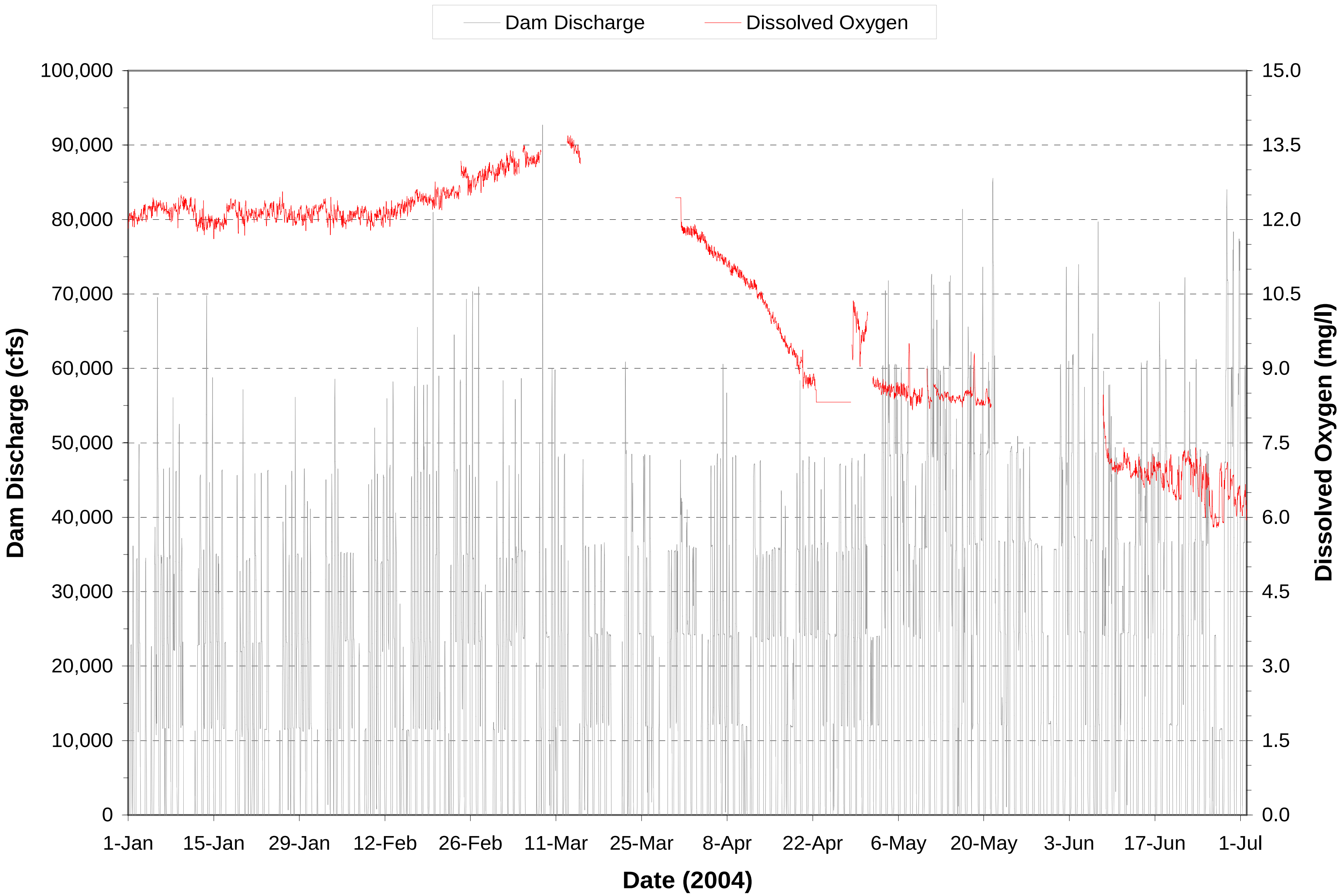


Plate 195. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

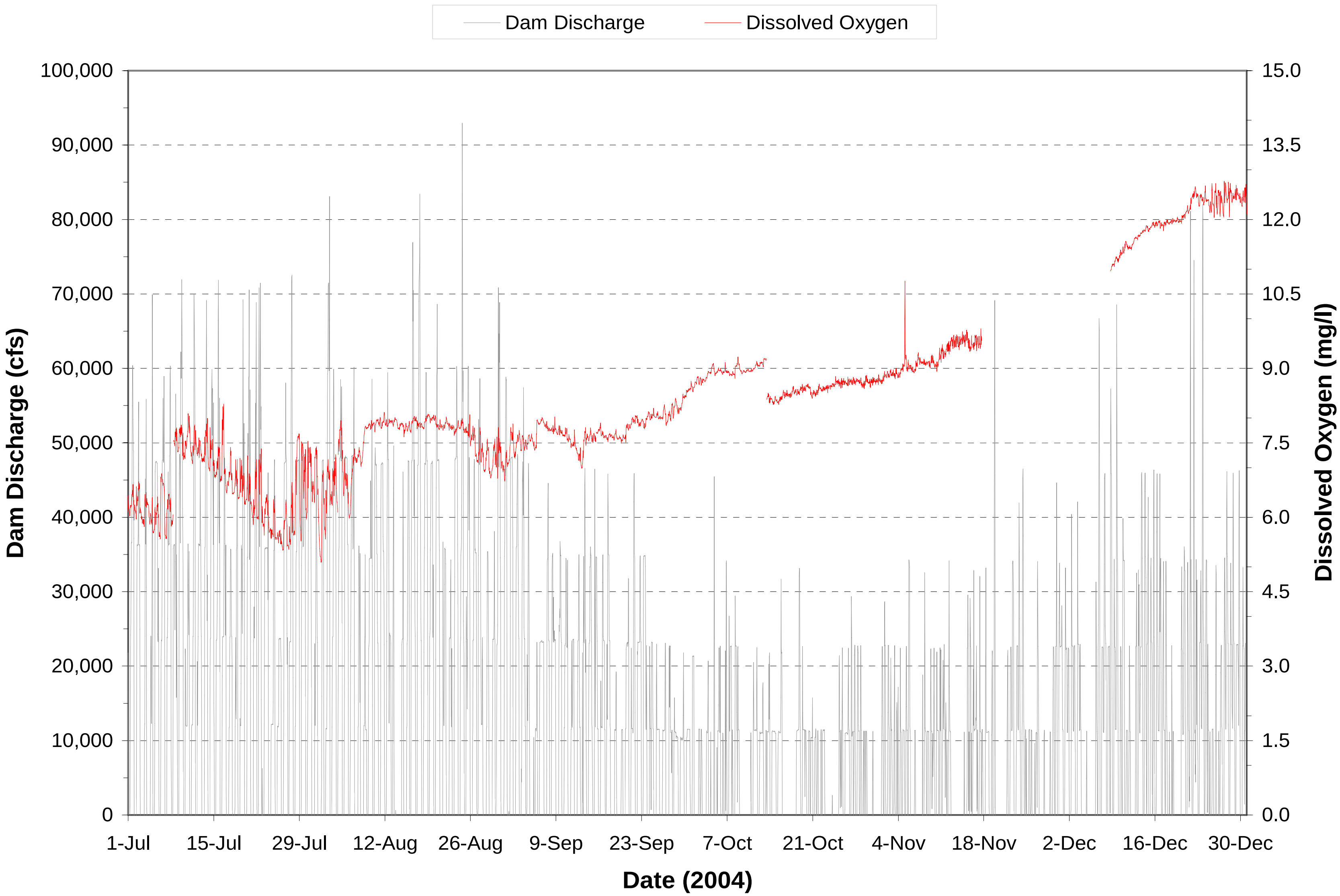


Plate 196. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

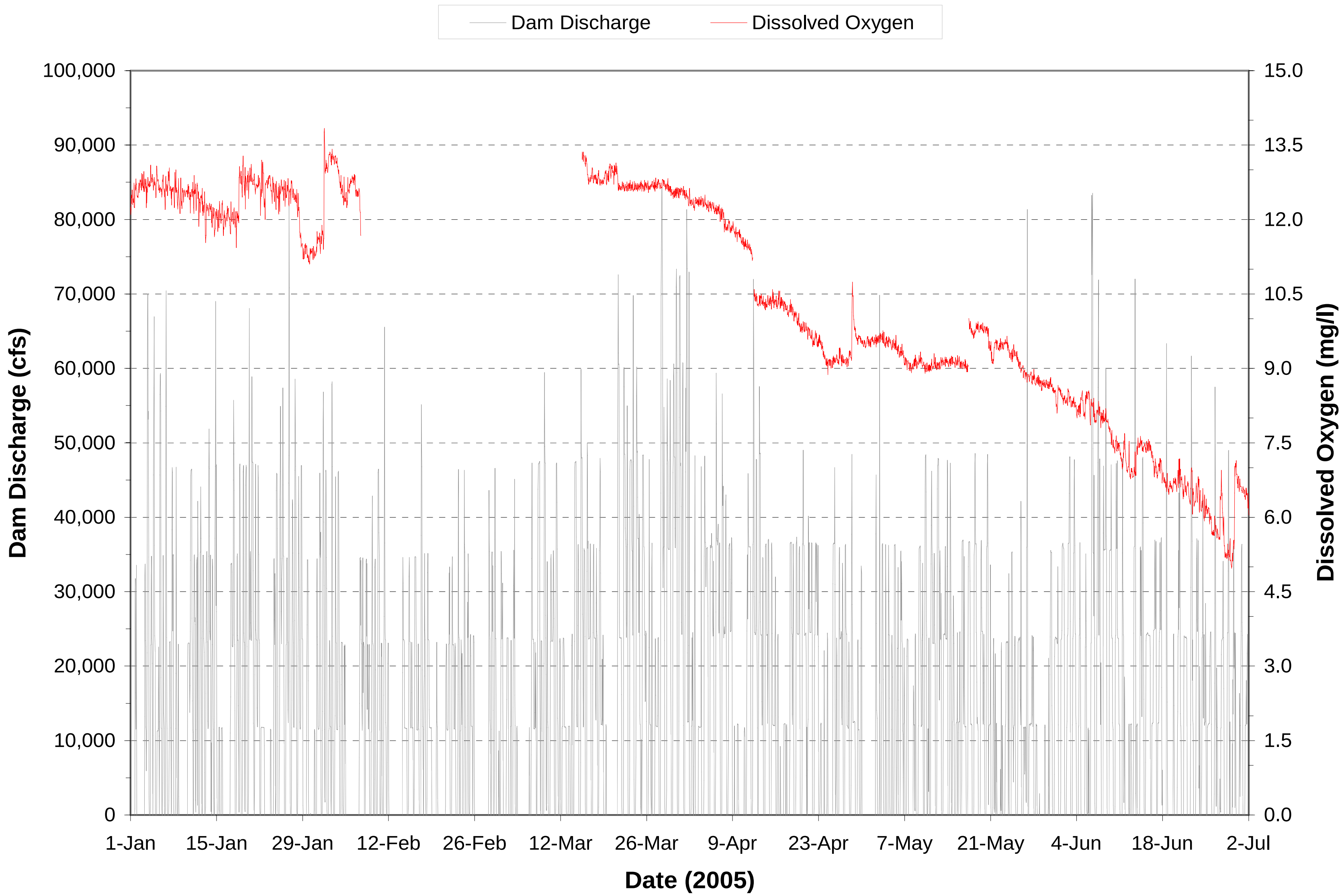


Plate 197. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

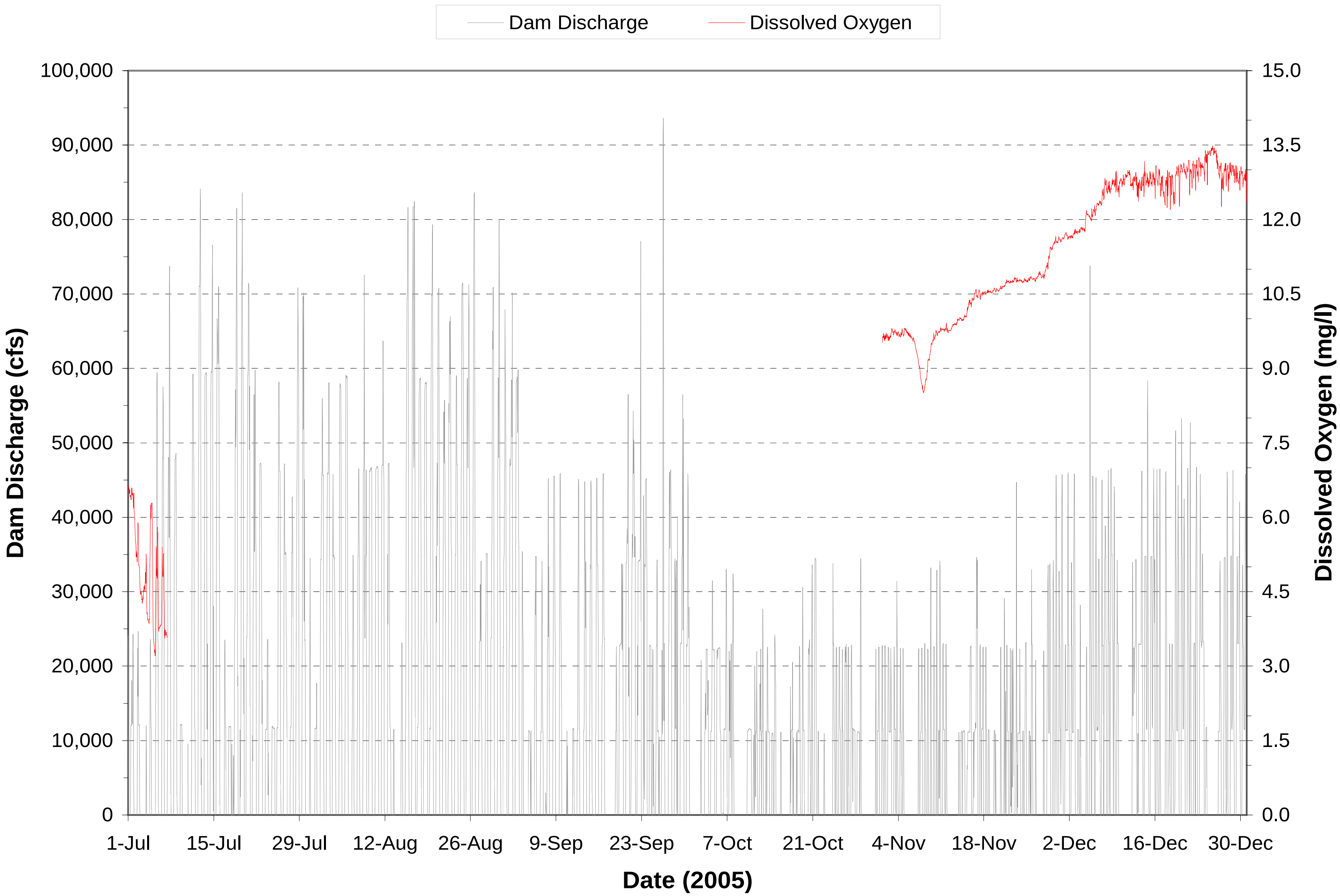


Plate 198. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

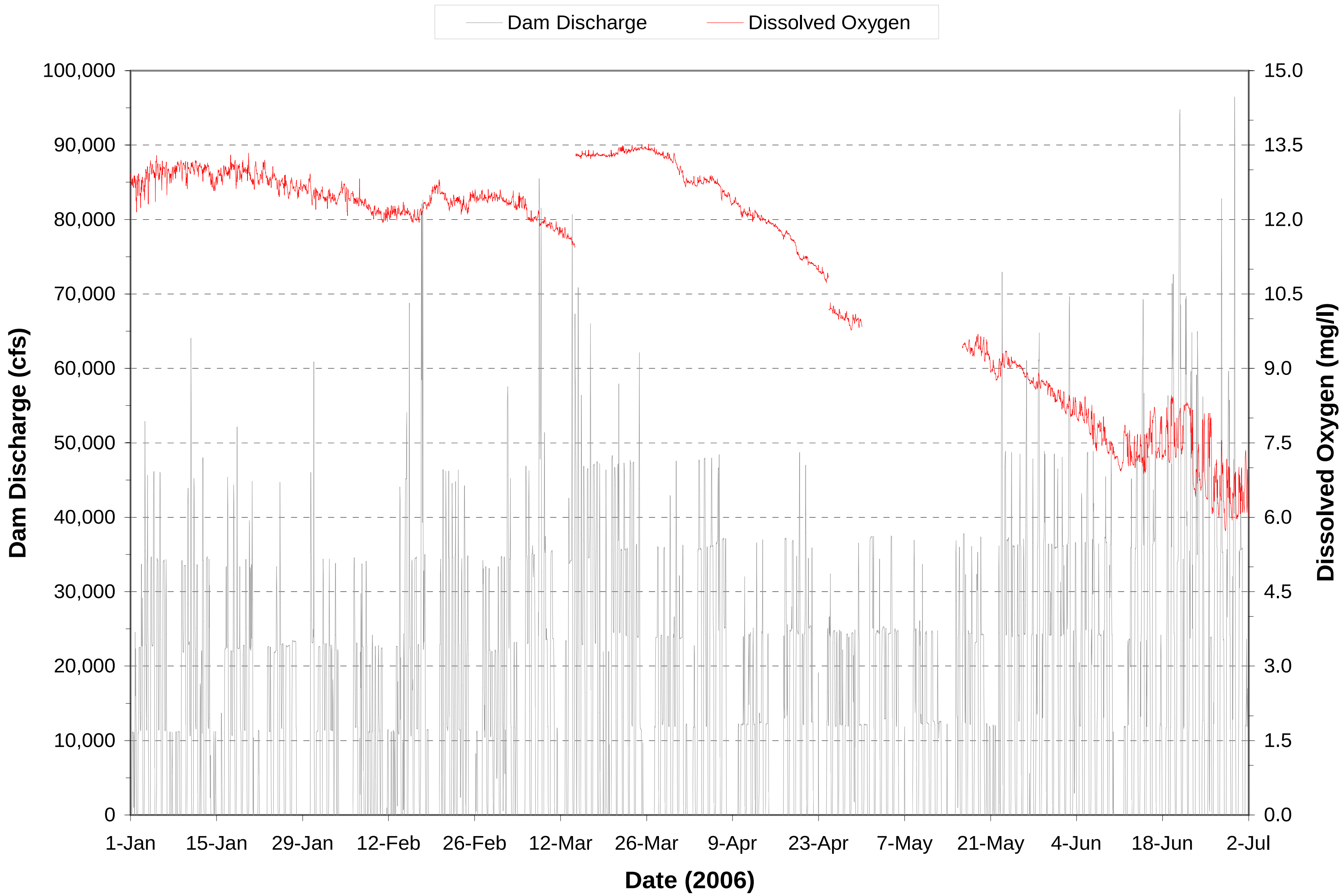


Plate 199. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period January through July 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

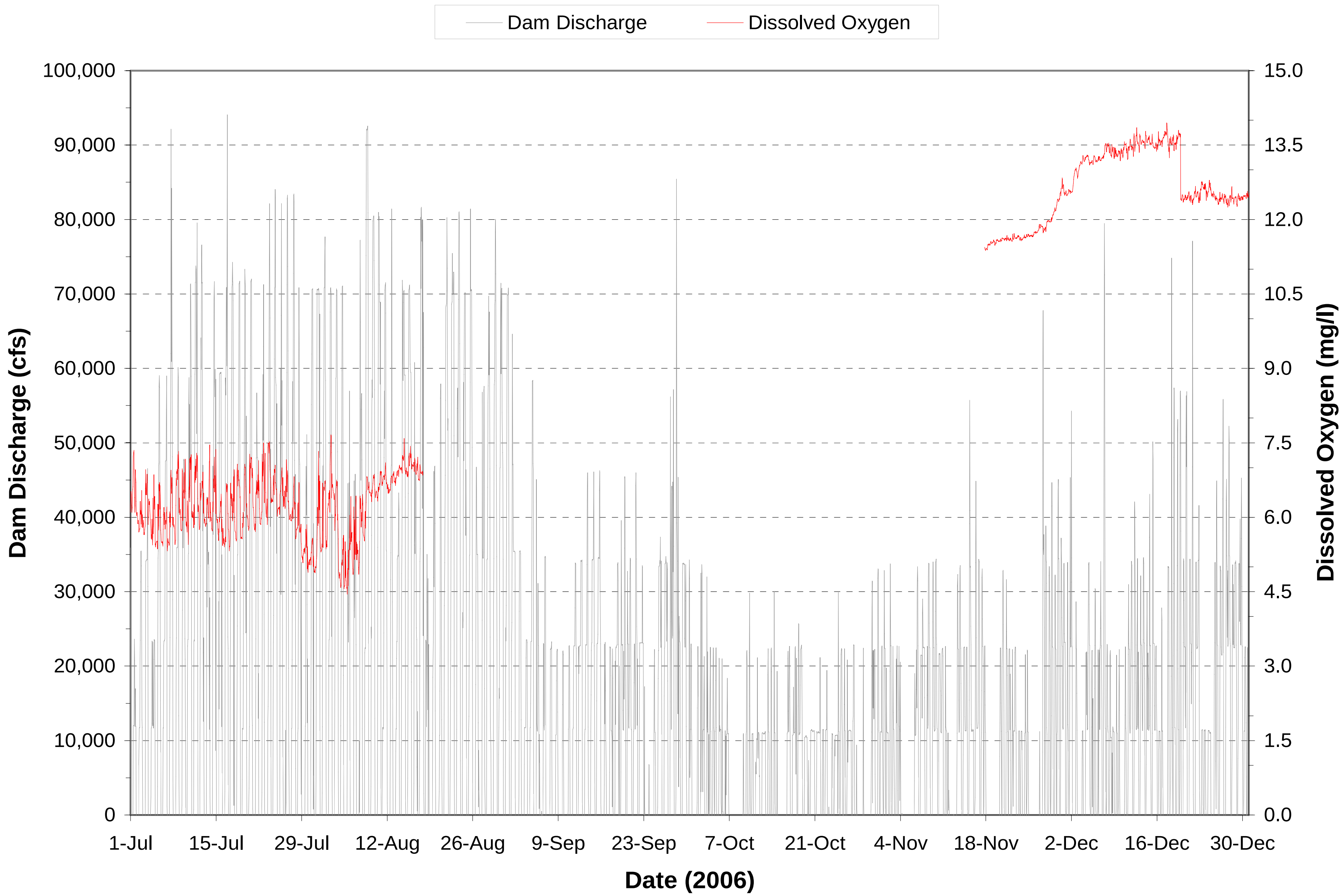


Plate 200. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

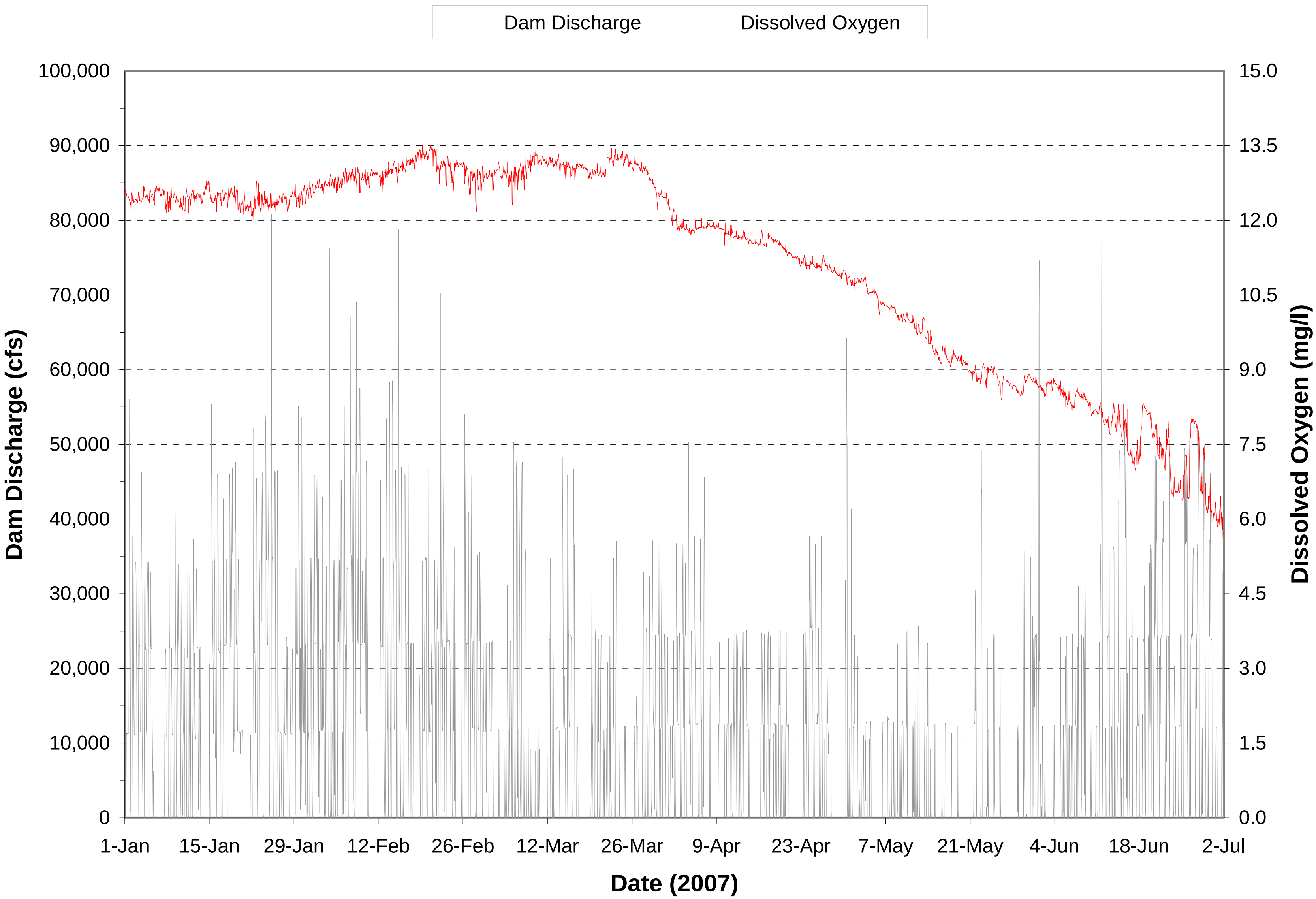


Plate 201. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period January through July 2007.

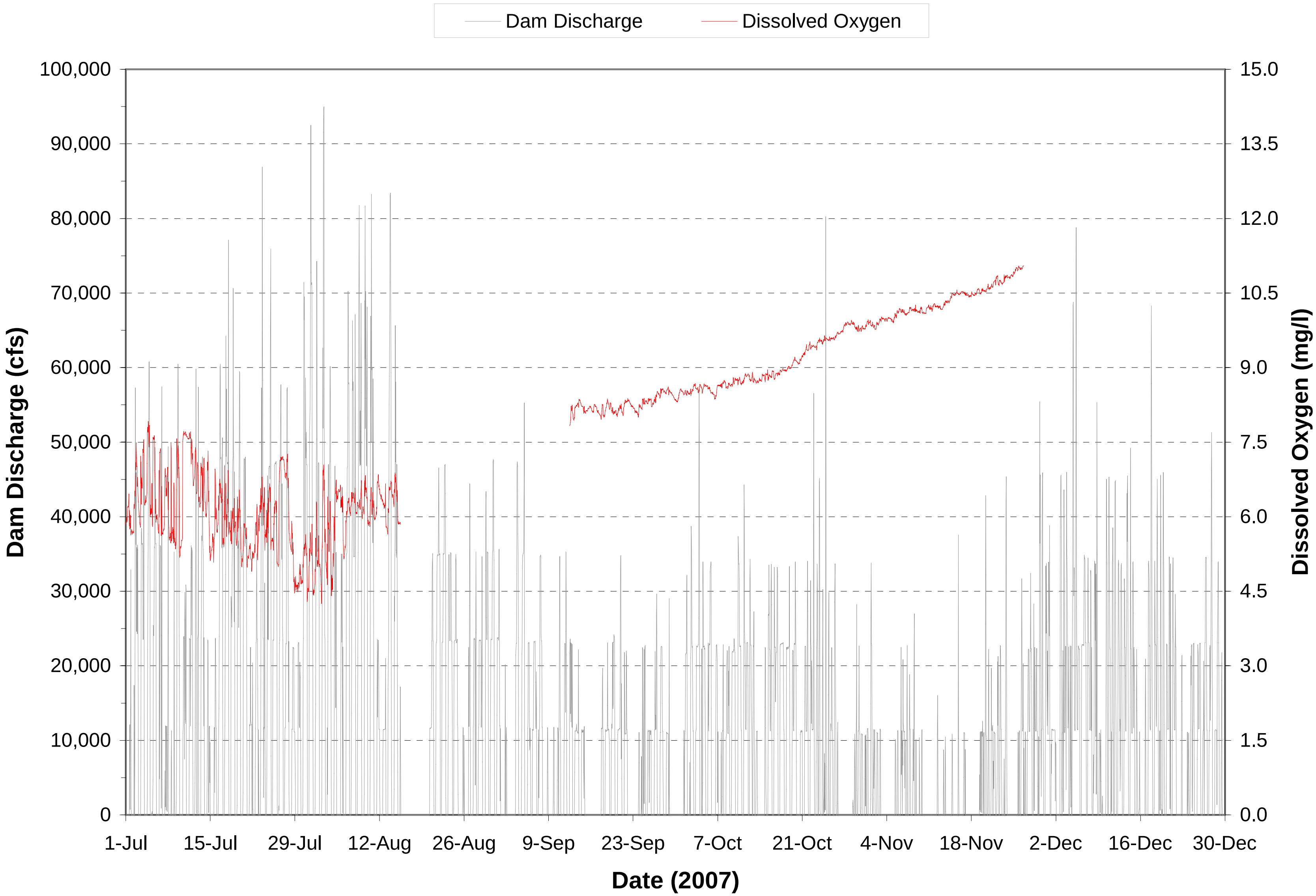


Plate 202. Hourly discharge and dissolved oxygen concentrations monitored at the Big Bend powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

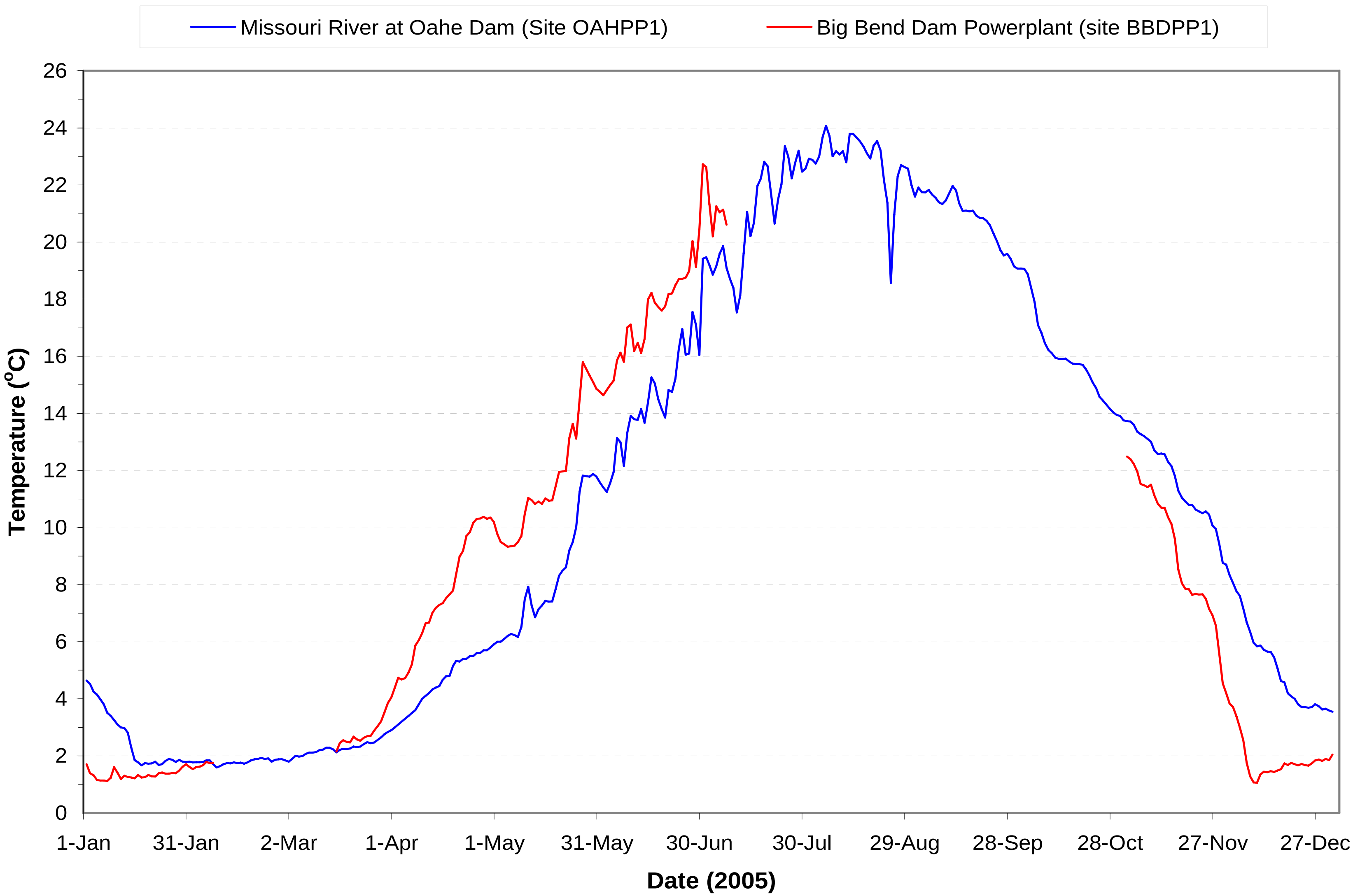


Plate 203. Mean daily water temperatures monitored at the Big Bend Powerplant (i.e., site BBDPP1) and the Missouri River at Oahe Dam (i.e., site OAHPP1) during 2005. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

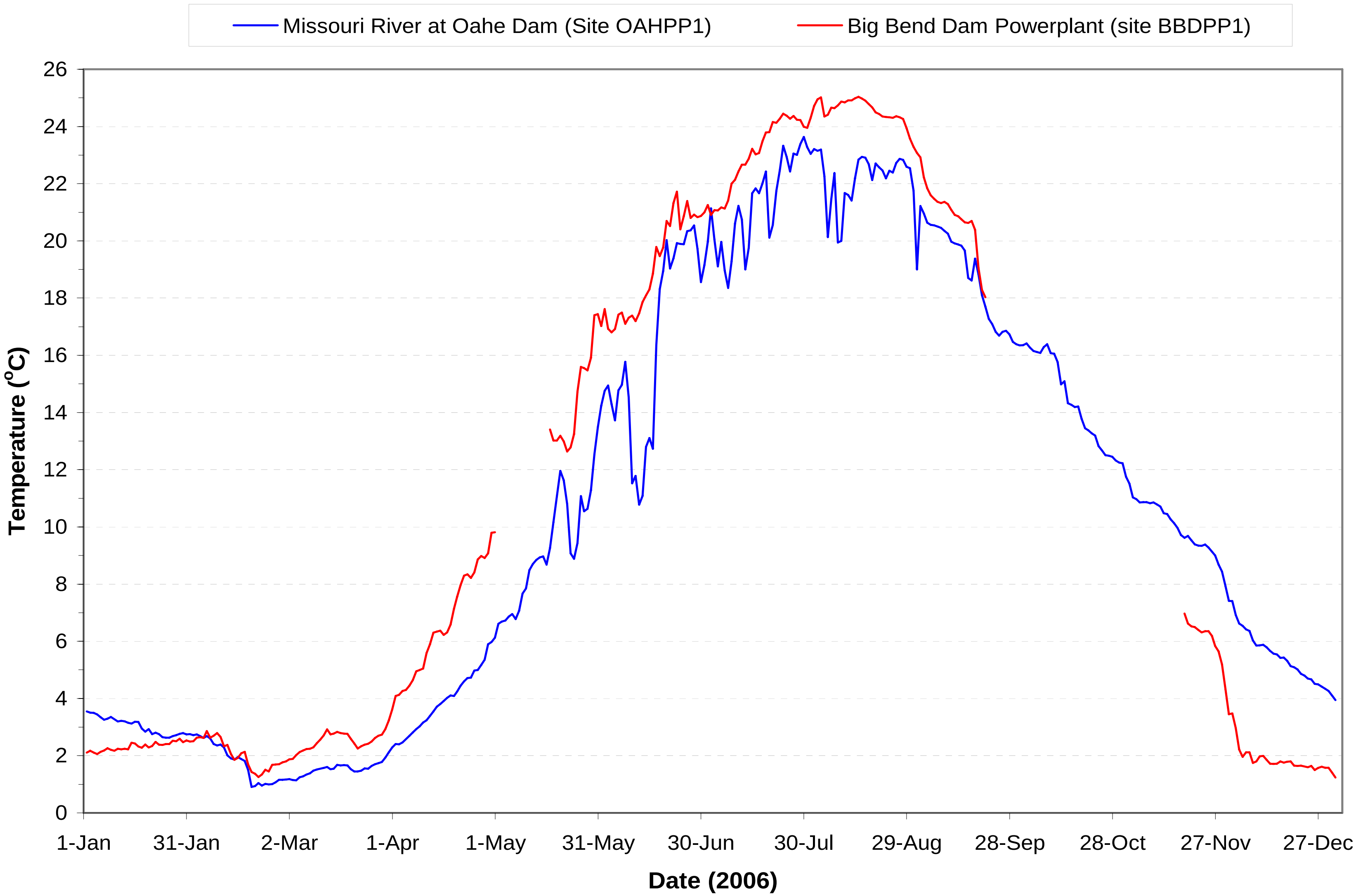


Plate 204. Mean daily water temperatures monitored at the Big Bend Powerplant (i.e., site BBDPP1) and the Missouri River at Oahe Dam (i.e., site OAHPP1) during 2006. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

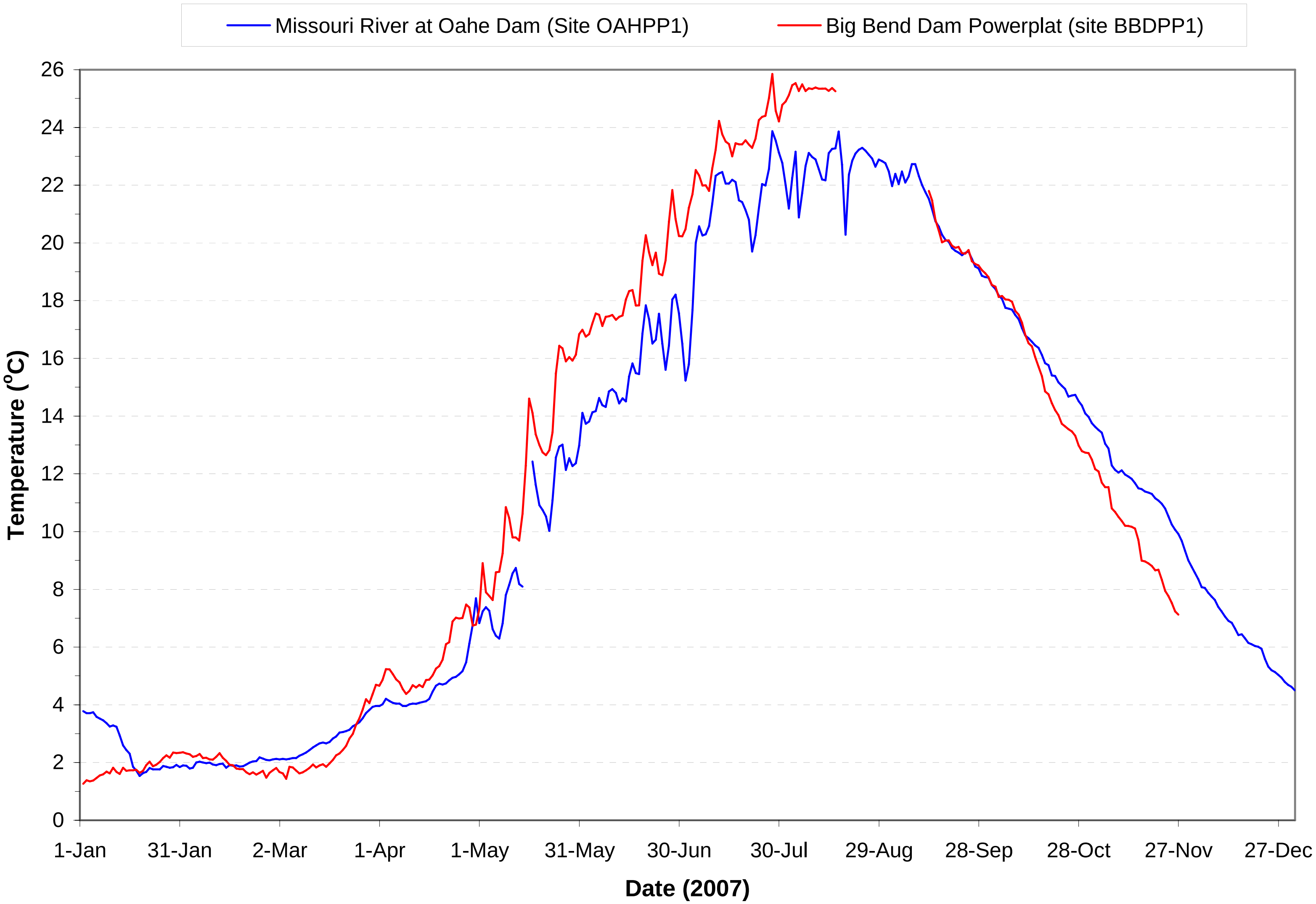


Plate 205. Mean daily water temperatures monitored at the Big Bend Powerplant (i.e., site BBDPP1) and the Missouri River at Oahe Dam (i.e., site OAHPP1) during 2007. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

Plate 206. Summary of monthly (May through September) water quality conditions monitored in Fort Randall Reservoir near Fort Randall Dam (Site FTRLK0880A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	25	1353.8	1354.1	1346.7	1356.9	-----	-----	-----
Water Temperature (C)	0.1	830	19.0	20.8	5.6	28.1	27.0	3	<1%
Dissolved Oxygen (mg/l)	0.1	827	8.2	7.9	1.8	12.8	≥ 5.0	30	4%
Dissolved Oxygen (% Sat.)	0.1	827	91.0	93.2	20.7	108.4	-----	-----	-----
Specific Conductance (umho/cm)	1	830	702	728	571	789	-----	-----	-----
pH (S.U.)	0.1	757	8.4	8.3	7.4	9.3	≥6.5 & ≤9.0[(1)]	23	3%
Turbidity (NTUs)	0.1	788	4.0	2.9	0.1	32.1	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	830	364	363	281	441	-----	-----	-----
Secchi Depth (in.)	1	26	115	111	51	229	-----	-----	-----
Alkalinity, Total (mg/l)	7	50	168	170	140	202	-----	-----	-----
Ammonia, Total (mg/l)	0.01	50	-----	0.07	n.d.	1.30	3.15 [(2,3)], 0.97 [(2,4)]	0, 1	0%, 2%
Carbon, Total Organic (mg/l)	0.05	48	3.0	3.1	1.7	3.6	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	22	10	10	n.d.	21	-----	-----	-----
Chloride (mg/l)	1	22	10	10	9	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	643	-----	1	n.d.	9	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	24	-----	1	n.d.	3	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	24	476	470	440	550	1,750[(5)]	0	0%
Iron, Dissolved (ug/l)	40	15	-----	n.d.	n.d.	80	-----	-----	-----
Iron, Total (ug/l)	40	15	86	80	n.d.	194	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	50	0.4	0.3	n.d.	2.2	-----	-----	-----
Manganese, Dissolved (ug/l)	1	15	21	8	n.d.	112	-----	-----	-----
Manganese, Total (ug/l)	1	15	37	17	5	141	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	50	-----	n.d.	n.d.	0.24	10[(5)]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	19	-----	n.d.	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	50	-----	0.02	n.d.	0.25	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	48	-----	n.d.	n.d.	0.08	-----	-----	-----
Sulfate (mg/l)	1	24	217	220	186	230	875[(5)]	0	0%
Suspended Solids, Total (mg/l)	4	50	-----	n.d.	n.d.	8	158[(3)], 90[(4)]	0	0%
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	1.8	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The pH criteria of 6.5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.
(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(3) Acute criterion for aquatic life.
(4) Chronic criterion for aquatic life.
(5) Daily maximum criterion for domestic water supply.

Plate 207. Summary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near Pease Creek (site FTRHLK0892DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	8	1353.5	1354.4	1346.7	1356.3	-----	-----	-----
Water Temperature (C)	0.1	230	22.1	23.0	12.3	26.2	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	229	7.5	7.8	1.5	8.8	≥ 5.0	10	4%
Dissolved Oxygen (% Sat.)	0.1	229	89.8	93.0	18.0	102.3	-----	-----	-----
Specific Conductance (umho/cm)	1	230	731	734	698	740	-----	-----	-----
pH (S.U.)	0.1	230	8.5	8.5	7.9	9.3	≥6.5 & ≤9.0[(1)]	23	10%
Turbidity (NTUs)	0.1	229	3.2	2.2	0.6	24.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	230	342	333	271	427	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	228	2	1	n.d.	4	-----	-----	-----
Secchi Depth (in)	1	7	111	96	56	194	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The pH criteria of 6 5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.

Plate 208. Summary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near Platte Creek (Site FTRLK0911DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	8	1353.6	1354.4	1346.7	1356.3	-----	-----	-----
Water Temperature (C)	0.1	193	22.6	22.4	14.2	26.5	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	193	7.5	7.8	3.0	8.6	≥ 5.0	6	3%
Dissolved Oxygen (% Sat.)	0.1	193	90.5	92.9	34.2	103.4	-----	-----	-----
Specific Conductance (umho/cm)	1	193	727	730	708	742	-----	-----	-----
pH (S.U.)	0.1	193	8.5	8.5	7.9	9.3	≥6.5 & ≤9.0(1)	19	10%
Turbidity (NTUs)	0.1	193	4.4	3.1	1.3	25.8	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	193	340	334	276	425	-----	-----	-----
Secchi Depth (in.)	1	8	91	86	48	148	-----	-----	-----
Alkalinity, Total (mg/l)	7	15	154	157	110	170	-----	-----	-----
Ammonia, Total (mg/l)	0.01	15	-----	0.03	n.d.	0.16	2.14 (2,3), 0.62 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	13	3.0	3.0	2.5	3.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	15	11	11	n.d.	19	-----	-----	-----
Chloride (mg/l)	1	15	11	11	9	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	191	3	2	n.d.	11	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	8	4	4	2	10	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	15	481	480	456	510	1,750(5)	0	0%
Iron, Dissolved (ug/l)	40	15	-----	n.d.	n.d.	40	-----	-----	-----
Iron, Total (ug/l)	40	15	108	100	40	240	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	15	0.3	0.3	n.d.	0.7	-----	-----	-----
Manganese, Dissolved (ug/l)	1	15	-----	3	n.d.	70	-----	-----	-----
Manganese, Total (ug/l)	1	15	48	30	10	160	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	15	-----	n.d.	n.d.	0.19	10(5)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	15	-----	n.d.	n.d.	0.04	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	15	-----	0.02	n.d.	0.04	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	15	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	15	213	219	180	270	875(5)	0	0%
Suspended Solids, Total (mg/l)	4	15	-----	n.d.	n.d.	15	158(3), 90(4)	0	0%
Microcystins, Total (ug/l)	0.2	8	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The pH criteria of 6.5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.
(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(3) Acute criterion for aquatic life.
(4) Chronic criterion for aquatic life.
(5) Daily maximum criterion for domestic water supply.

Plate 209. Summary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near Snake Creek (site FTRHLK0924DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	8	1353.5	1354.4	1347.1	1356.3	-----	-----	-----
Water Temperature (C)	0.1	142	23.3	24.0	15.3	27.2	27.0	1	<1%
Dissolved Oxygen (mg/l)	0.1	142	7.8	7.9	3.2	8.5	≥ 5.0	1	<1%
Dissolved Oxygen (% Sat.)	0.1	142	94.7	96.0	39.4	107.8	-----	-----	-----
Specific Conductance (umho/cm)	1	142	722	723	693	738	-----	-----	-----
pH (S.U.)	0.1	142	8.5	8.5	8.2	9.1	≥6.5 & ≤9.0(1)	15	11%
Turbidity (NTUs)	0.1	141	7.9	6.8	1.6	57.9	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	142	345	322	272	498	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	141	4	1	n.d.	21	-----	-----	-----
Secchi Depth (in)	1	8	53	55	25	84	-----	-----	-----

* Results are a combination of all sampling depths.

** The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

*** (1) The pH criteria of 6 5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.

Plate 210. **S**ummary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near Elm Creek (Site FTRLK0940DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	7	1353.7	1354.4	1347.1	1356.3	-----	-----	-----
Water Temperature (C)	0.1	33	23.3	24.6	13.8	26.4	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	33	8.3	8.1	7.8	9.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	33	101.2	101.4	92.1	112.9	-----	-----	-----
Specific Conductance (umho/cm)	1	33	727	732	716	738	-----	-----	-----
pH (S.U.)	0.1	33	8.6	8.6	8.2	9.1	≥6.5 & ≤9.0 (1)	6	18%
Turbidity (NTUs)	0.1	33	36.0	13.0	2.5	283.5	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	33	330	316	265	400	-----	-----	-----
Secchi Depth (in.)	1	6	25	23	7	52	-----	-----	-----
Alkalinity, Total (mg/l)	7	14	148	160	140	170	-----	-----	-----
Ammonia, Total (mg/l)	0.01	14	-----	n.d.	n.d.	0.06	1.77 (2,3),0.46 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	12	3.0	3.1	1.7	3.5	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	14	13	12	4	30	-----	-----	-----
Chloride (mg/l)	1	14	10	10	9	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	33	5	5	n.d.	11	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	7	7	7	n.d.	10	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	14	474	475	444	540	1,750(5)	0	0%
Iron, Dissolved (ug/l)	40	14	-----	n.d.	n.d.	260	-----	-----	-----
Iron, Total (ug/l)	40	14	954	416	110	4,321	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	14	0.4	0.3	n.d.	1.0	-----	-----	-----
Manganese, Dissolved (ug/l)	1	14	-----	3	n.d.	13	-----	-----	-----
Manganese, Total (ug/l)	1	14	51	34	10	193	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	14	-----	n.d.	n.d.	0.11	10(5)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	14	-----	n.d.	n.d.	0.02	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	14	-----	0.04	n.d.	0.13	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	14	-----	n.d.	n.d.	0.02	-----	-----	-----
Sulfate (mg/l)	1	14	209	210	176	230	875(5)	0	0%
Suspended Solids, Total (mg/l)	4	14	28	10	n.d.	140	158(3), 90(4)	0, 2	0%, 14%
Microcystins, Total (ug/l)	0.2	7	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.
* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).
*** (1) The pH criteria of 6.5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.
(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(3) Acute criterion for aquatic life.
(4) Chronic criterion for aquatic life.
(5) Daily maximum criterion for domestic water supply.

Plate 211. Summary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near the White River (site FTRHLK0955DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	8	1353.5	1354.3	1347.1	1356.3	-----	-----	-----
Water Temperature (C)	0.1	36	23.1	24.6	14.9	26.0	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	35	8.3	8.1	7.8	9.2	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	35	100.6	101.5	94.2	102.9	-----	-----	-----
Specific Conductance (umho/cm)	1	36	716	714	689	735	-----	-----	-----
pH (S.U.)	0.1	36	8.6	8.5	8.3	9.0	≥6.5 & ≤9.0 (1)	0	0%
Turbidity (NTUs)	0.1	35	31.6	19.8	6.7	210.2	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	36	377	333	250	614	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	35	5	5	1	12	-----	-----	-----
Secchi Depth (in)	1	7	18	17	11	28	-----	-----	-----

* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).
*** (1) The pH criteria of 6 5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.

Plate 212. **S**ummary of monthly (June through September) water quality conditions monitored in Fort Randall Reservoir near Chamberlin, SD (Site FTRLK0968DW) during the 2-year period 2006 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	8	1353.5	1354.3	1347.1	1356.3	-----	-----	-----
Water Temperature (C)	0.1	51	22.6	24.2	15.6	26.2	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	51	8.3	8.1	7.7	9.1	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	51	99.1	99.6	92.7	108.6	-----	-----	-----
Specific Conductance (umho/cm)	1	51	716	715	688	732	-----	-----	-----
pH (S.U.)	0.1	51	8.5	8.5	8.3	9.0	≥6.5 & ≤9.0 (1)	0	0%
Turbidity (NTUs)	0.1	51	16.3	10.4	5.9	39.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	51	359	322	258	545	-----	-----	-----
Secchi Depth (in.)	1	8	24	24	14	32	-----	-----	-----
Alkalinity, Total (mg/l)	7	16	159	160	140	170	-----	-----	-----
Ammonia, Total (mg/l)	0.01	16	-----	0.03	n.d.	0.07	2.14 (2,3), 0.56 (2,4)	0	0%
Carbon, Total Organic (mg/l)	0.05	14	2.8	3.0	1.5	3.2	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	16	11	12	n.d.	20	-----	-----	-----
Chloride (mg/l)	1	16	10	10	9	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Field Probe	1	51	4	5	1	12	-----	-----	-----
Chlorophyll *a* (ug/l) – Lab Determined	1	8	5	6	n.d.	9	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	16	485	480	450	582	1,750(5)	0	0%
Iron, Dissolved (ug/l)	40	16	-----	n.d.	n.d.	560	-----	-----	-----
Iron, Total (ug/l)	40	16	424	415	130	680	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	16	0.4	0.3	n.d.	0.8	-----	-----	-----
Manganese, Dissolved (ug/l)	1	16	-----	4	n.d.	60	-----	-----	-----
Manganese, Total (ug/l)	1	16	58	60	30	86	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	16	-----	n.d.	n.d.	0.11	10(5)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	16	-----	0.01	n.d.	0.08	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	16	0.08	0.04	0.01	0 31	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	16	-----	n.d.	n.d.	0.02	-----	-----	-----
Sulfate (mg/l)	1	16	203	208	173	203	875(5)	0	0%
Suspended Solids, Total (mg/l)	4	16	13	12	5	27	158(3), 90(4)	0	0%
Microcystins, Total (ug/l)	0.2	8	n.d.	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.
* Results are a combination of all sampling depths.
** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).
*** (1) The pH criteria of 6.5 and 9.0 are, respectively, minimum and maximum criteria for the protection of warmwater permanent fish life propagation.
(2) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(3) Acute criterion for aquatic life.
(4) Chronic criterion for aquatic life.
(5) Daily maximum criterion for domestic water supply.

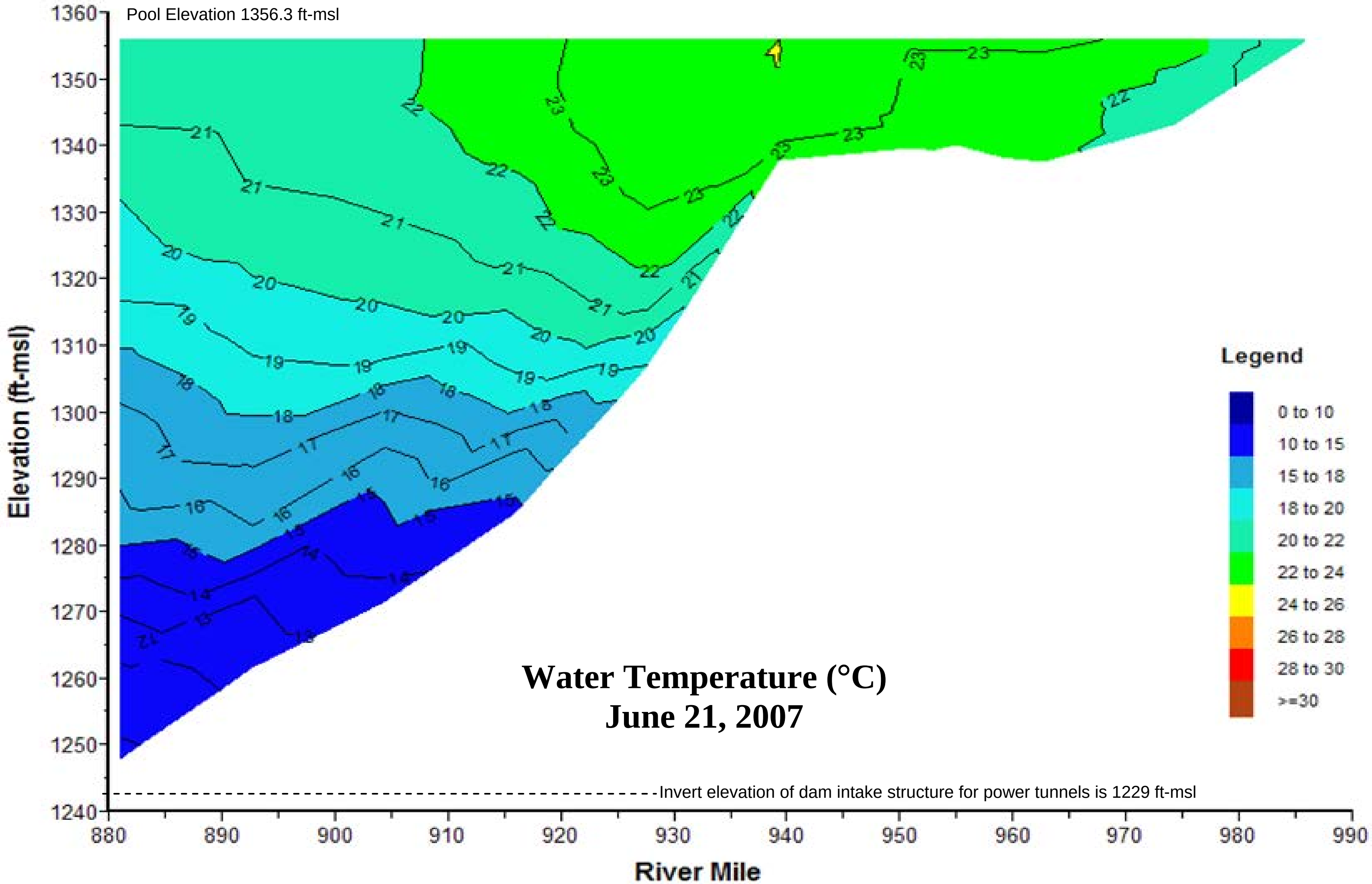


Plate 213. Longitudinal water temperature (°C) contour plot of Fort Randall Reservoir based on depth-profile water temperatures measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on June 21, 2007.

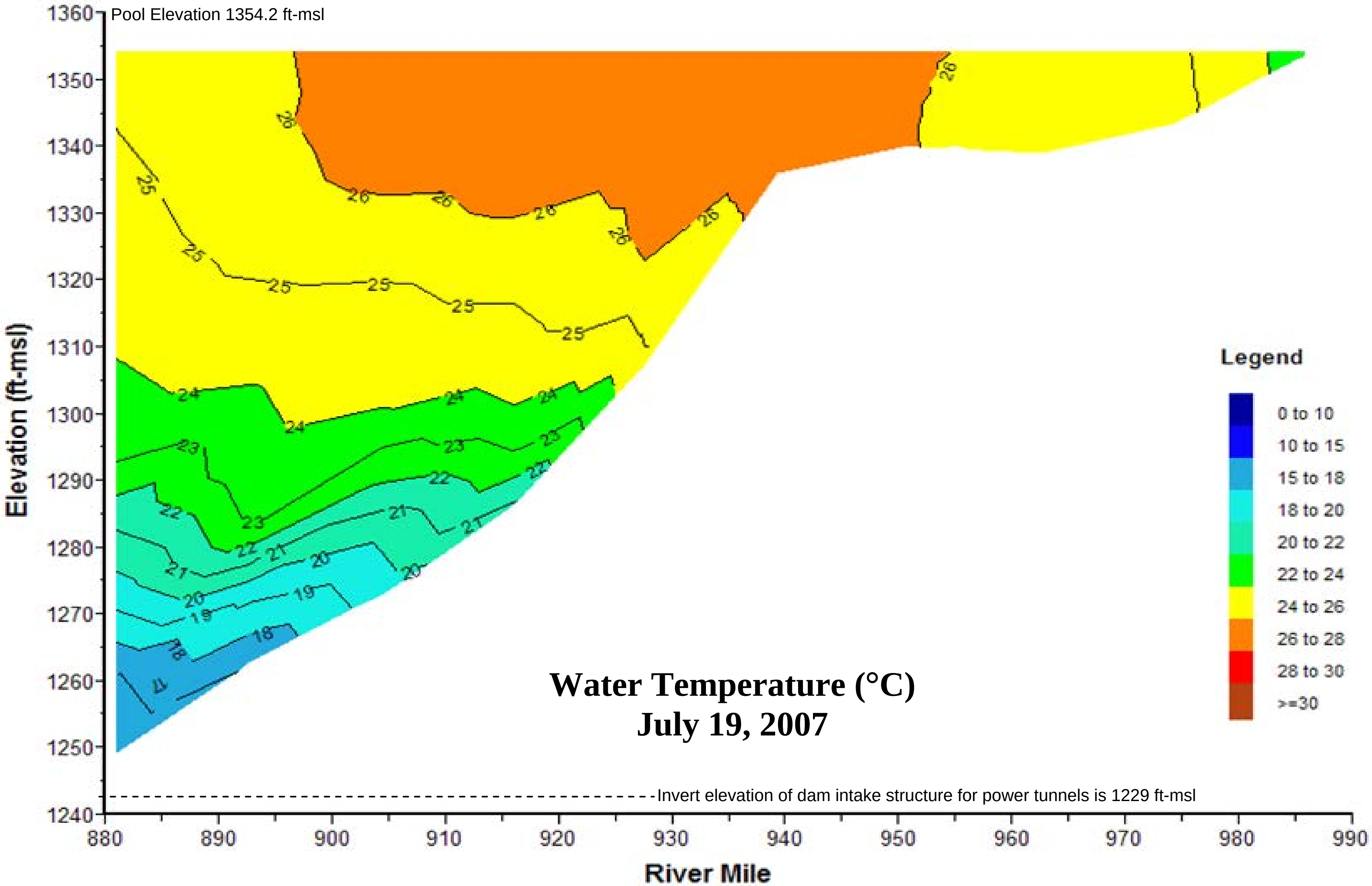


Plate 214. Longitudinal water temperature (°C) contour plot of Fort Randall Reservoir based on depth-profile water temperatures measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on July 19, 2007.

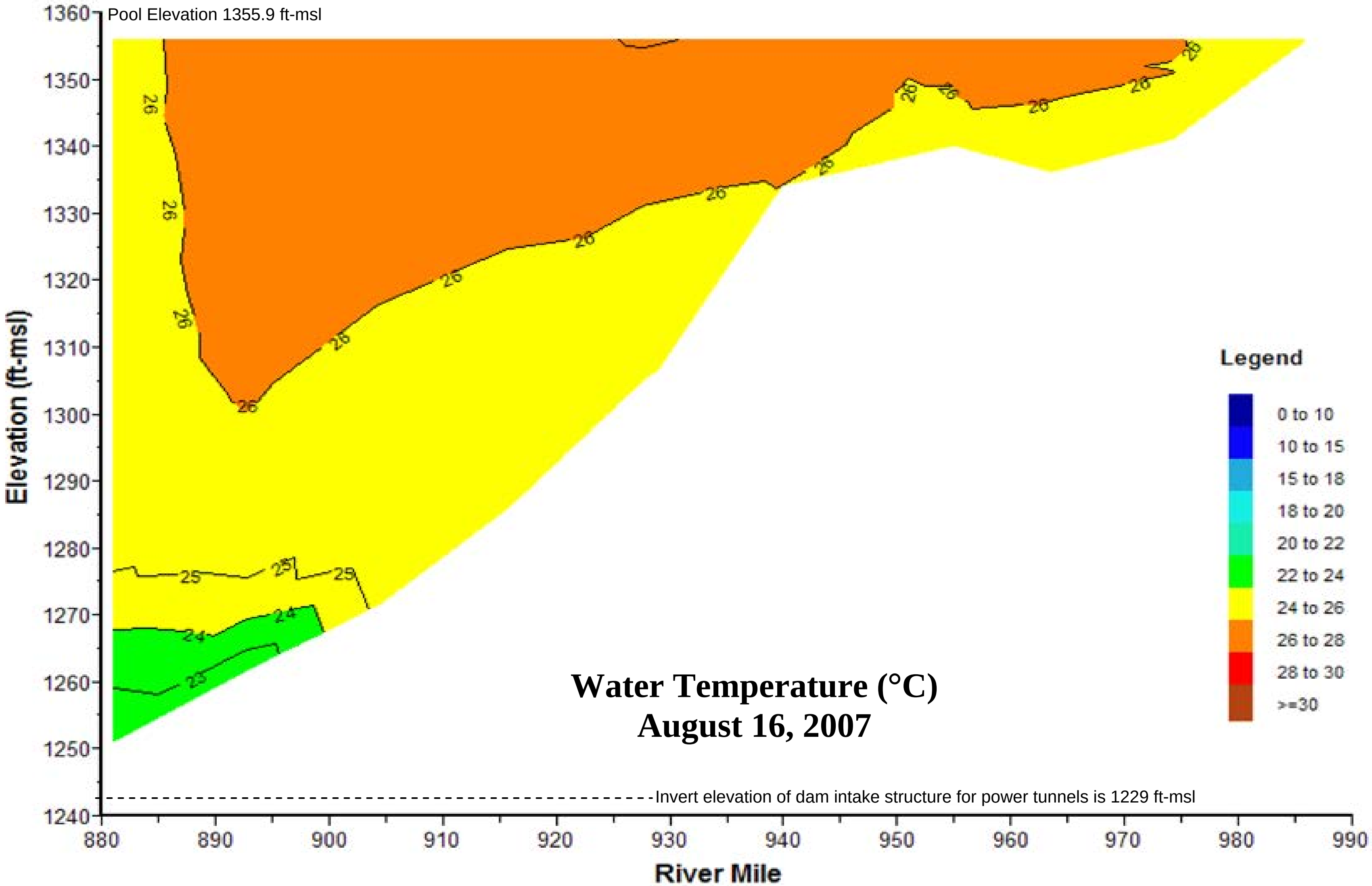


Plate 215. Longitudinal water temperature (°C) contour plot of Fort Randall Reservoir based on depth-profile water temperatures measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on August 16, 2007.

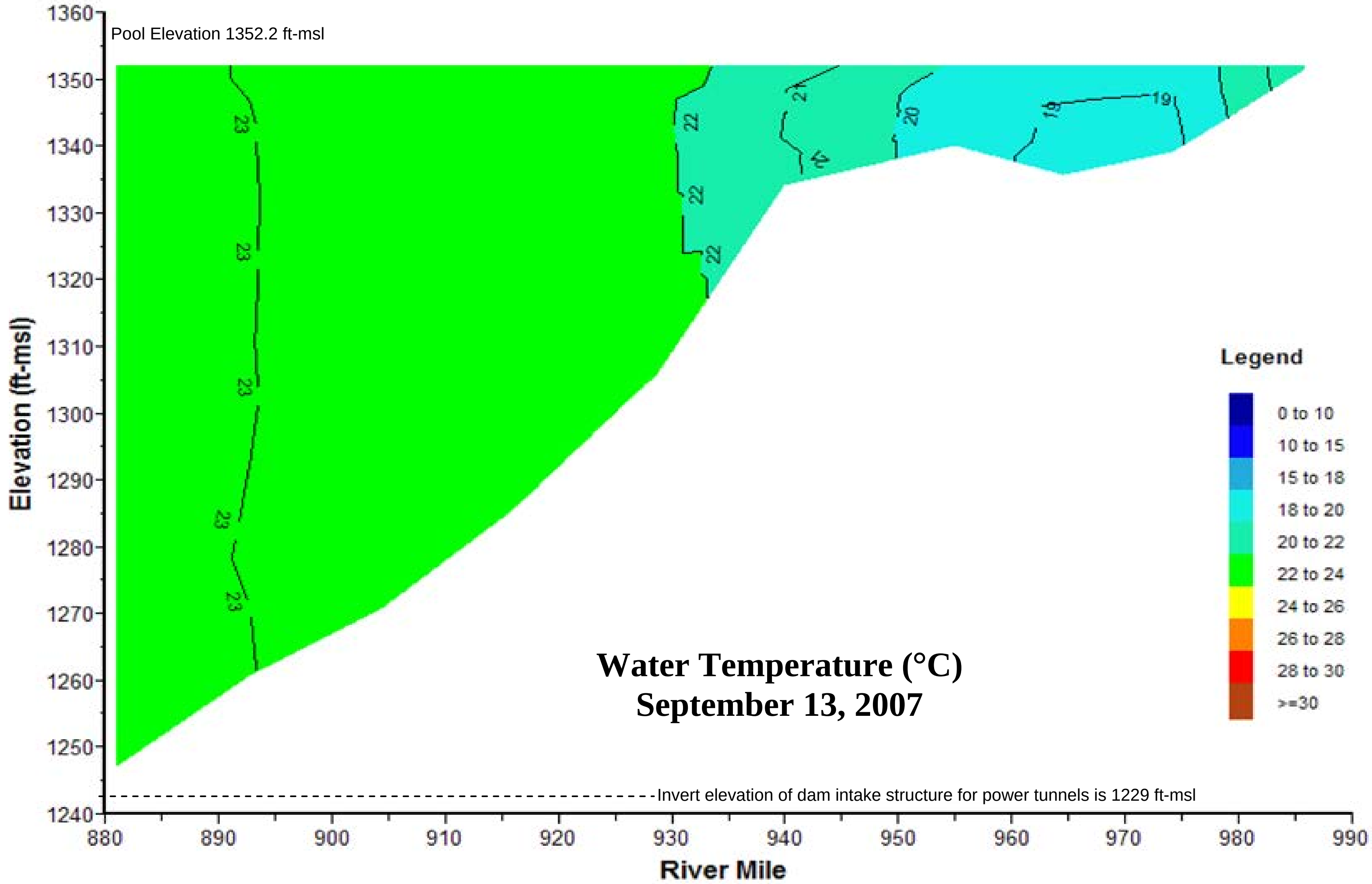


Plate 216. Longitudinal water temperature (°C) contour plot of Fort Randall Reservoir based on depth-profile water temperatures measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on September 13, 2007.

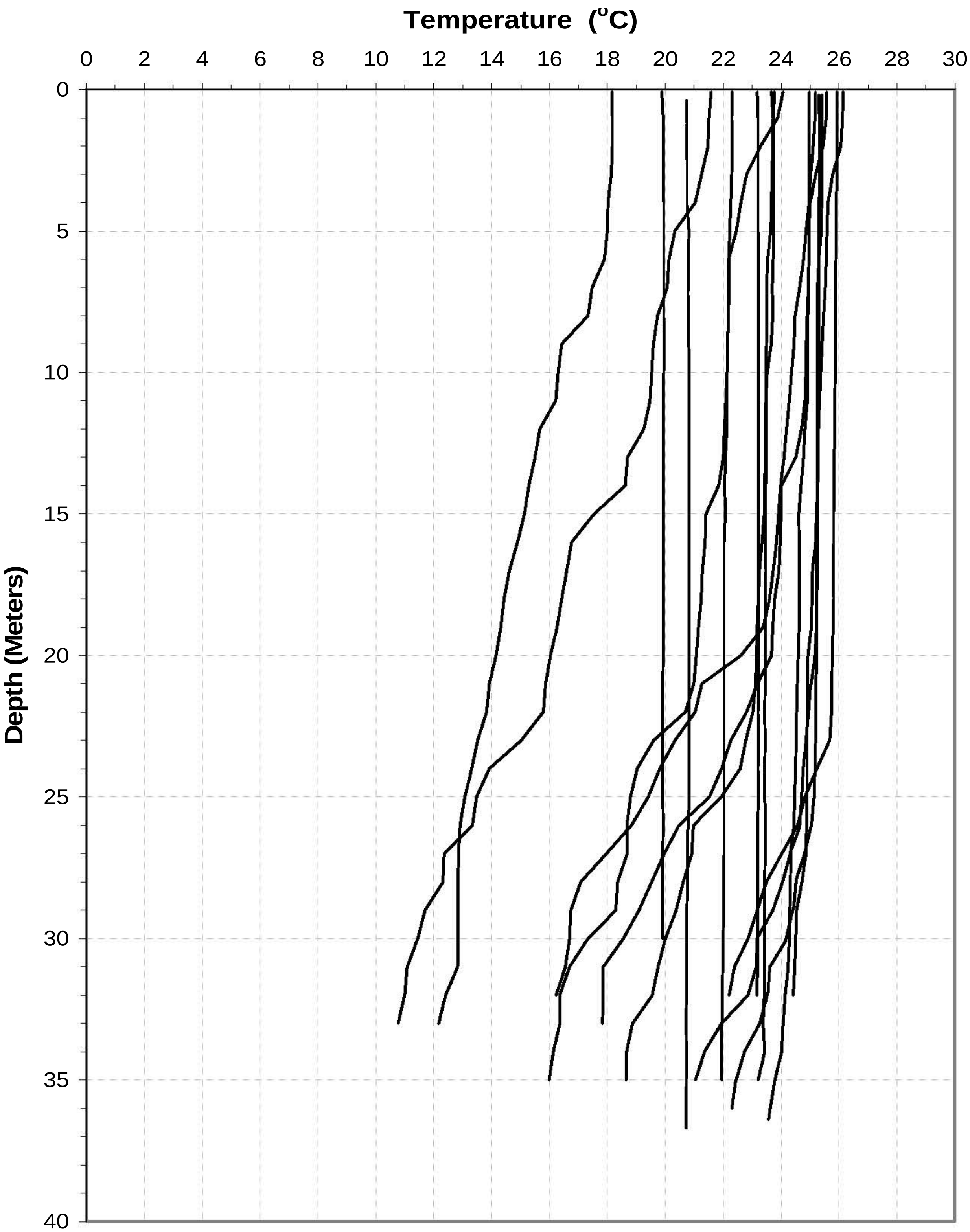


Plate 217. Temperature depth profiles for Fort Randall Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., site FTRLK0880A) during the summer months over the 5-year period of 2003 to 2007.

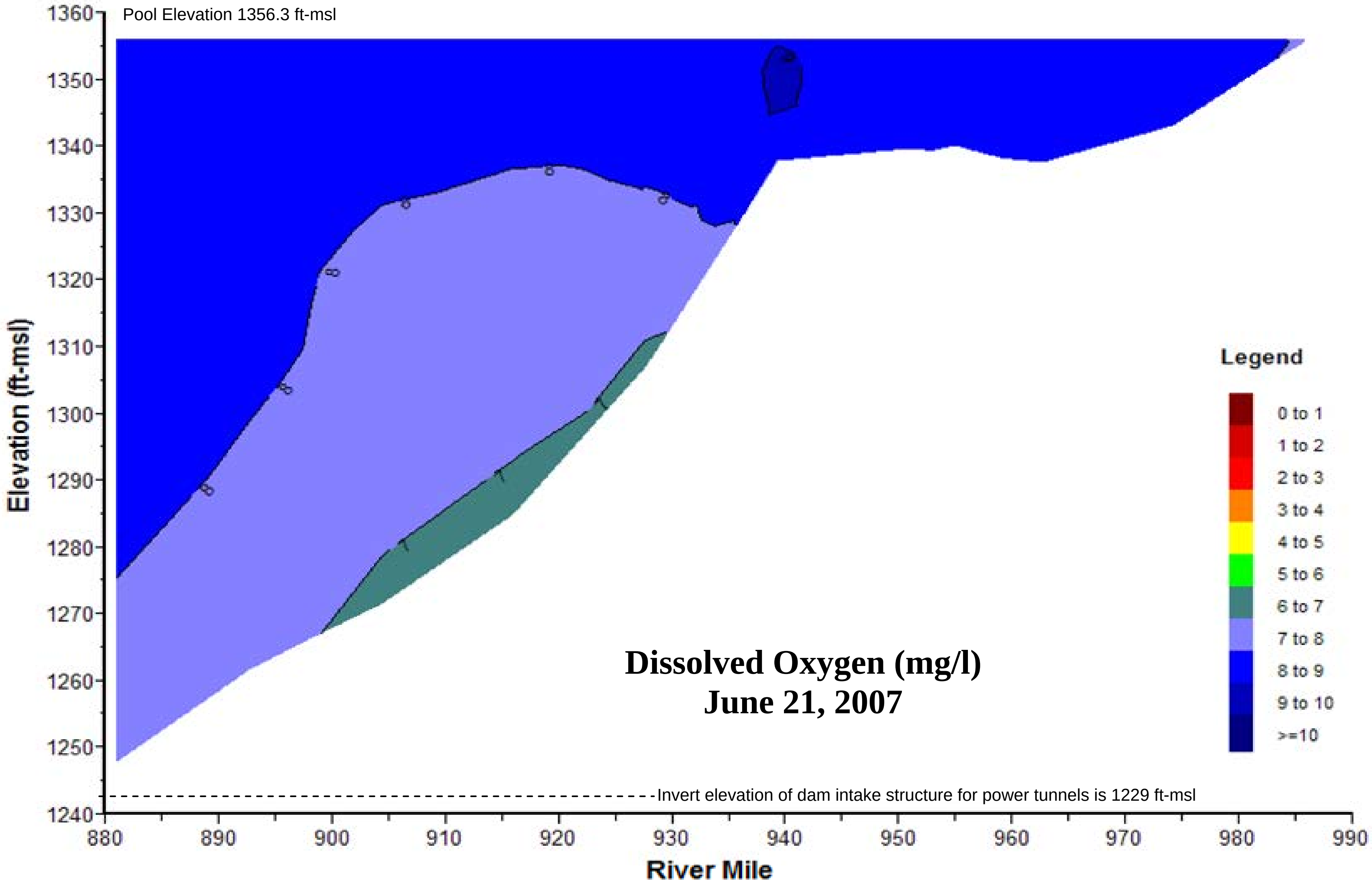


Plate 218. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on June 21, 2007.

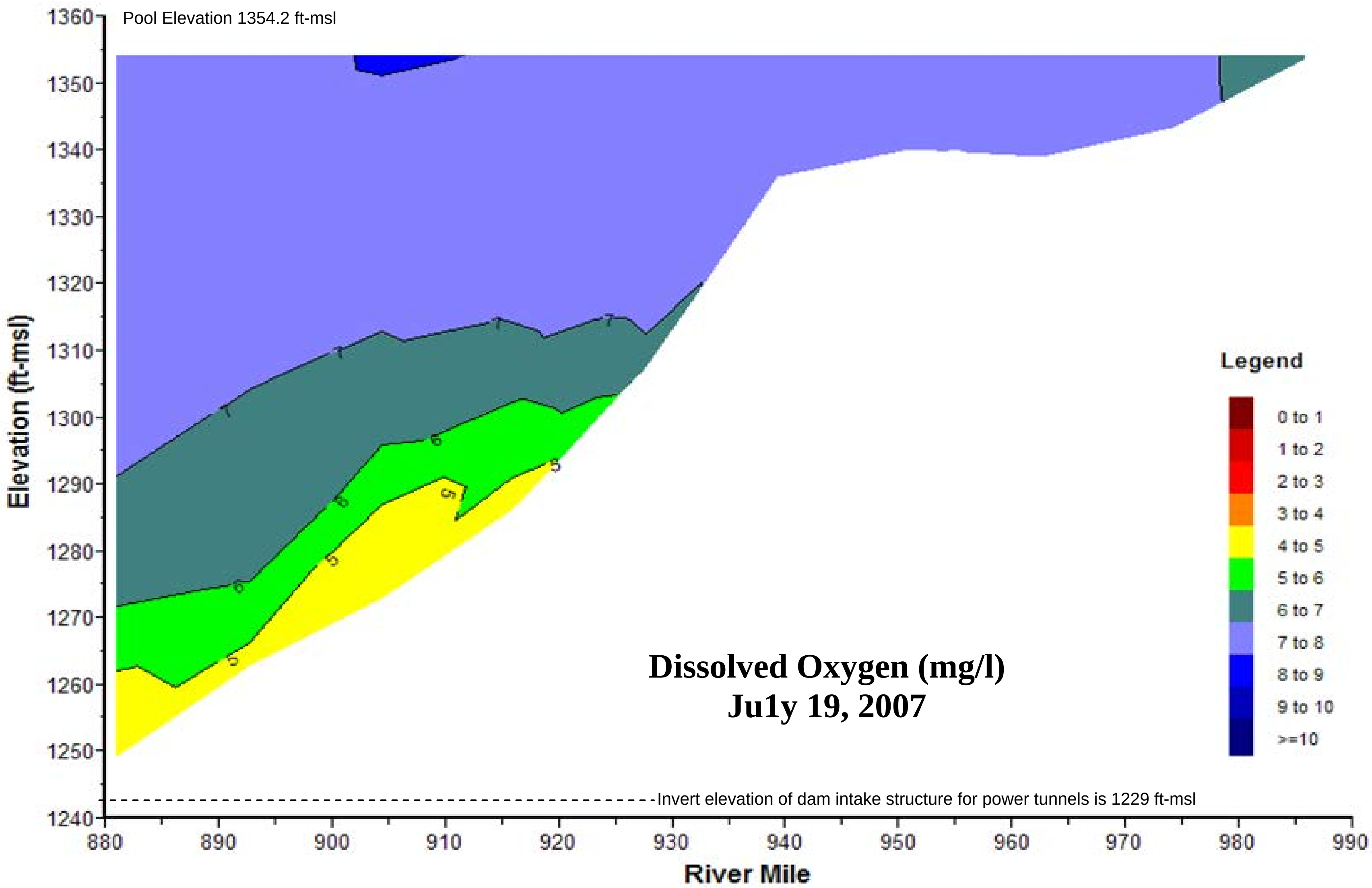


Plate 219. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on July 19, 2007.

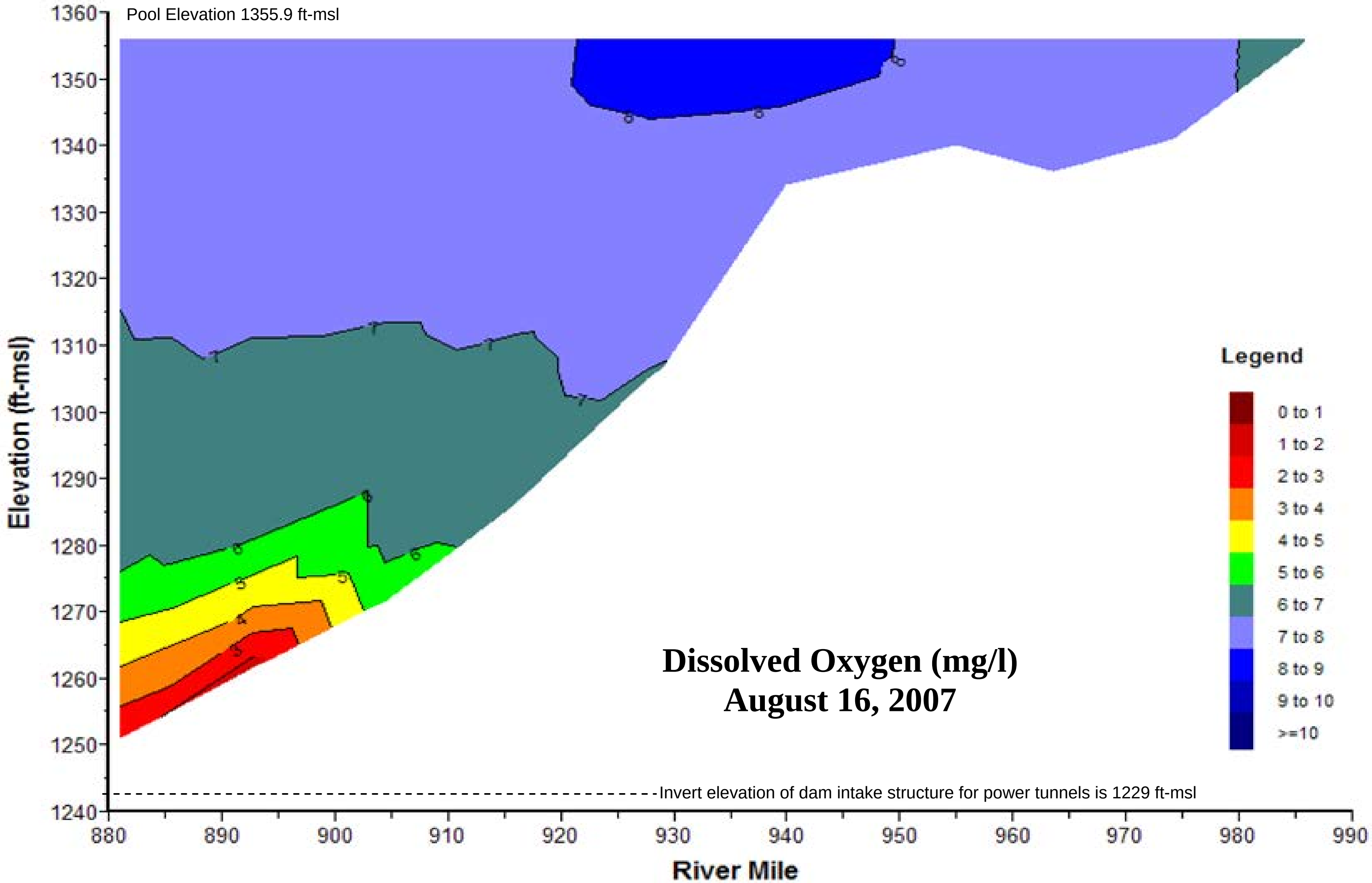


Plate 220. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on August 16, 2007.

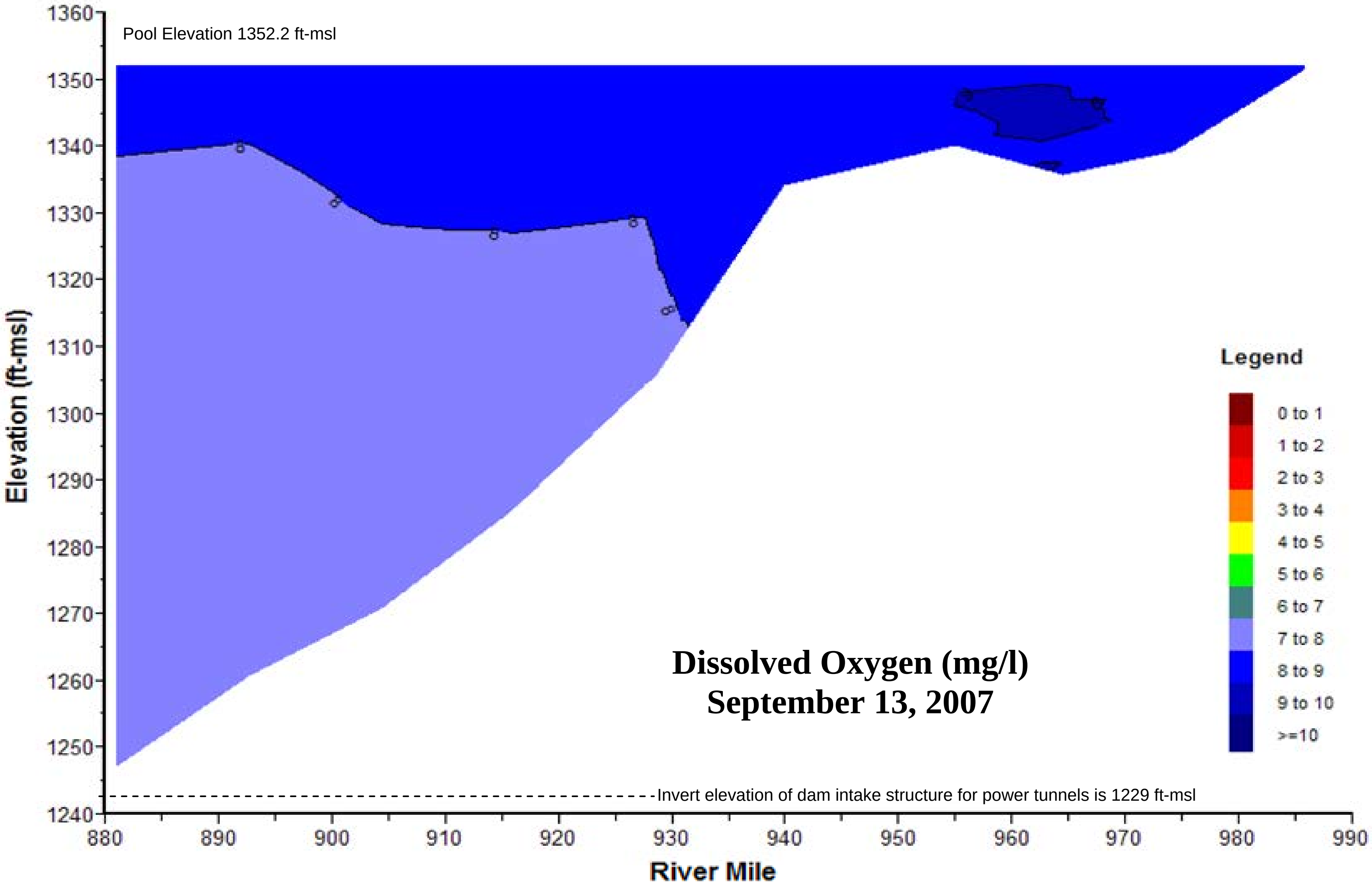


Plate 221. Longitudinal dissolved oxygen (mg/l) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on September 13, 2007.

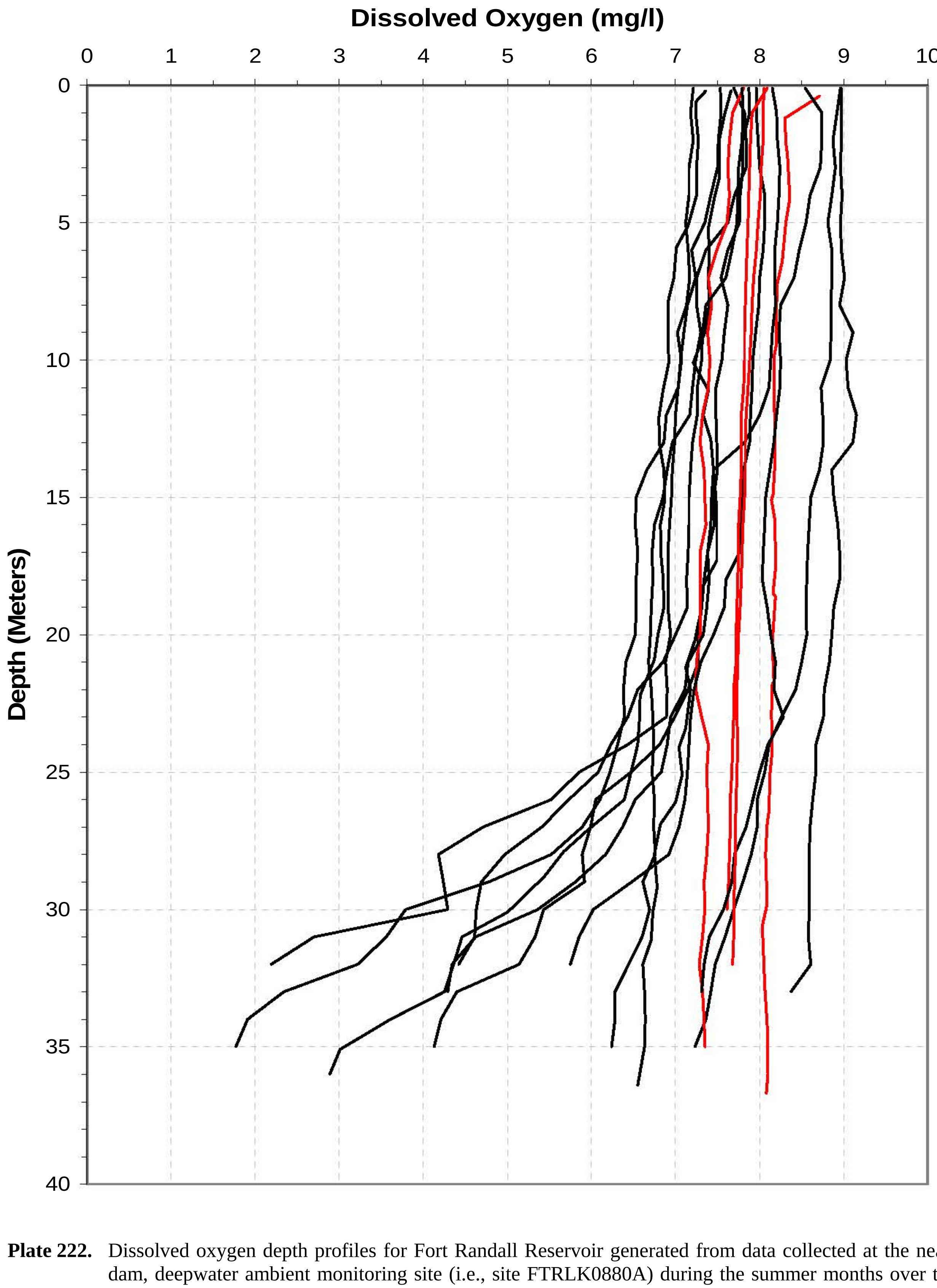


Plate 222. Dissolved oxygen depth profiles for Fort Randall Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., site FTRLK0880A) during the summer months over the 5-year period of 2003 to 2007. (Note: Red profile plots were measured in the month of September.)

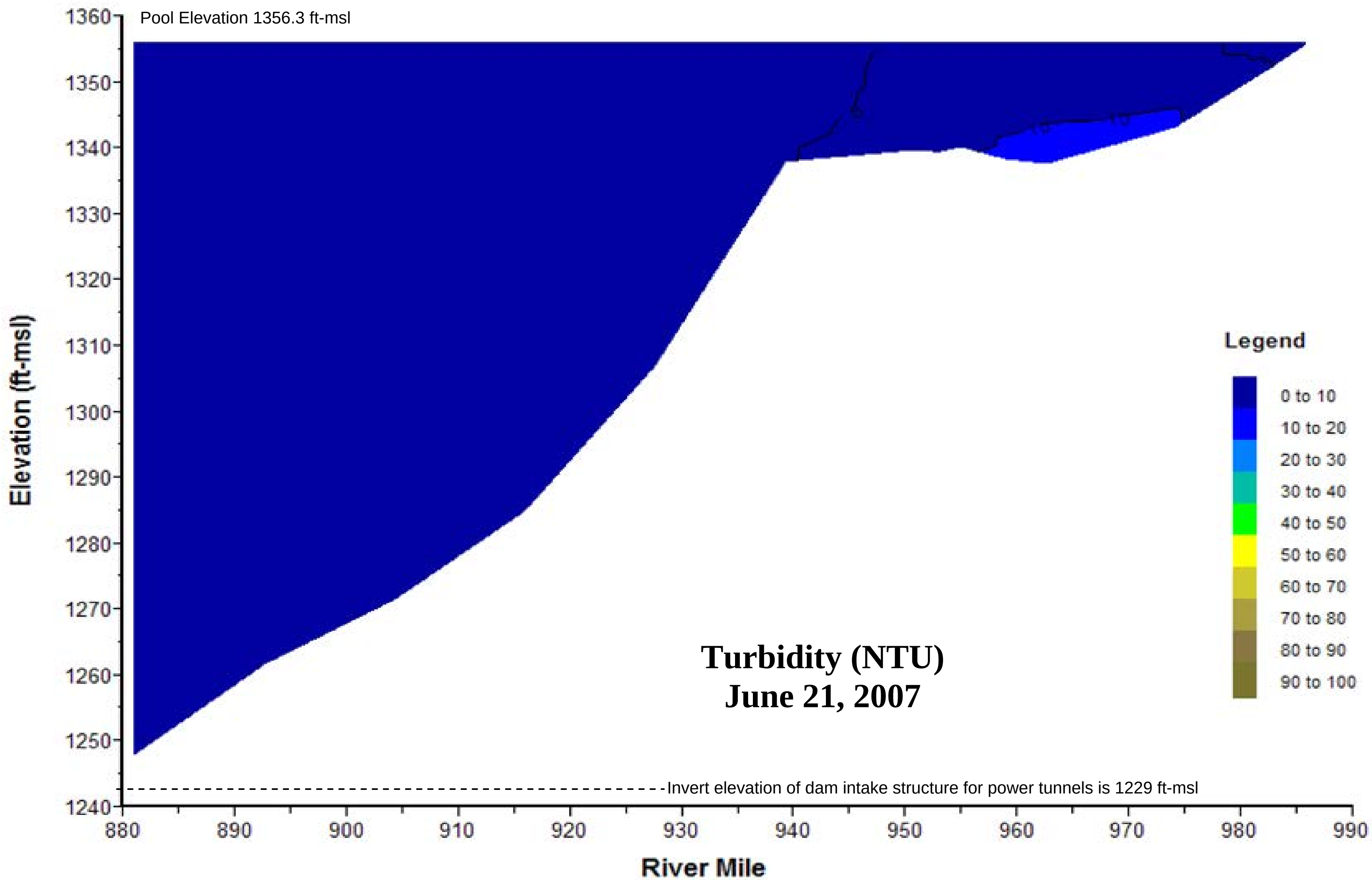


Plate 223. Longitudinal turbidity (NTU) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on June 21, 2007.

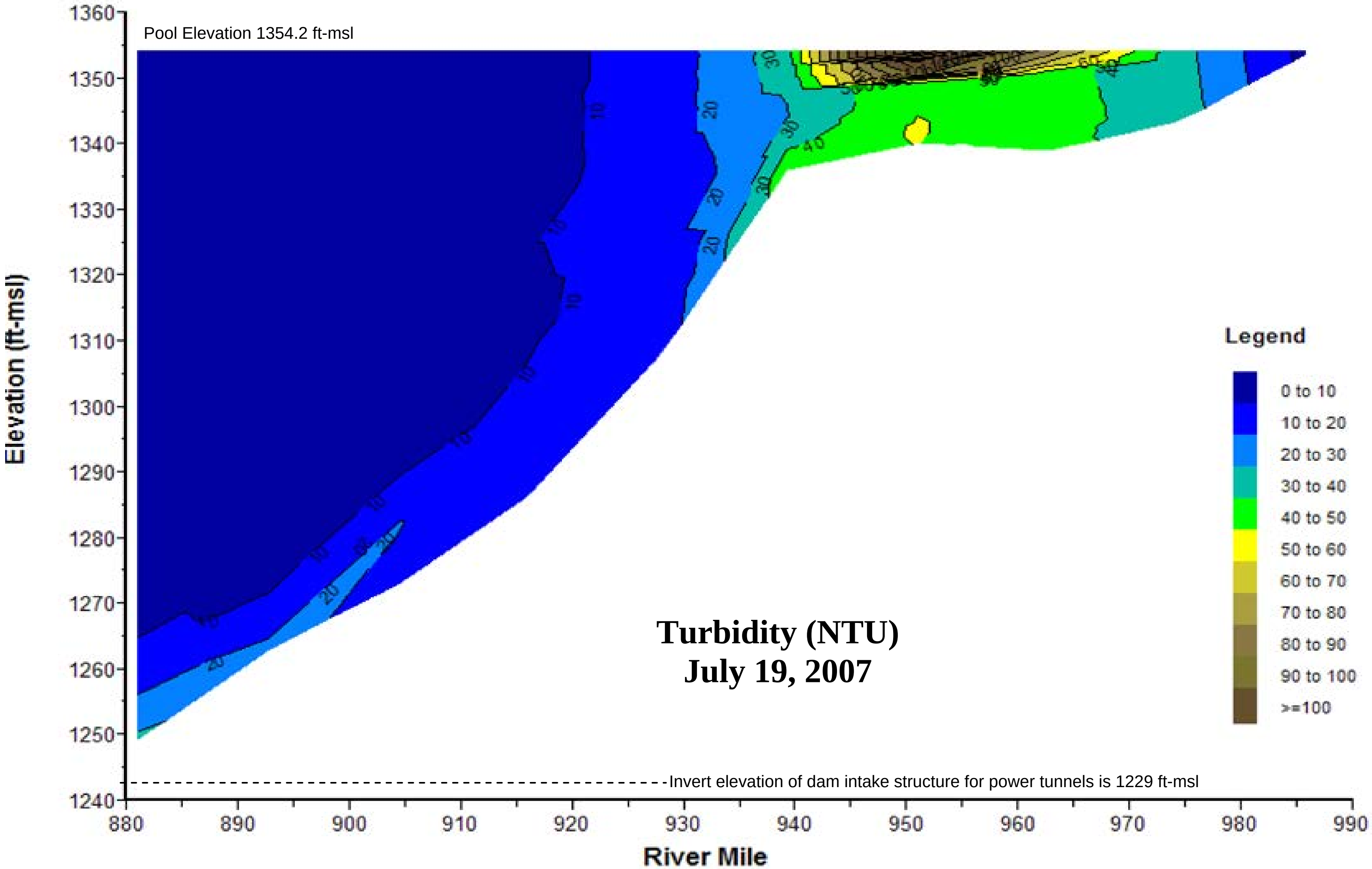


Plate 224. Longitudinal turbidity (NTU) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on July 19, 2007.

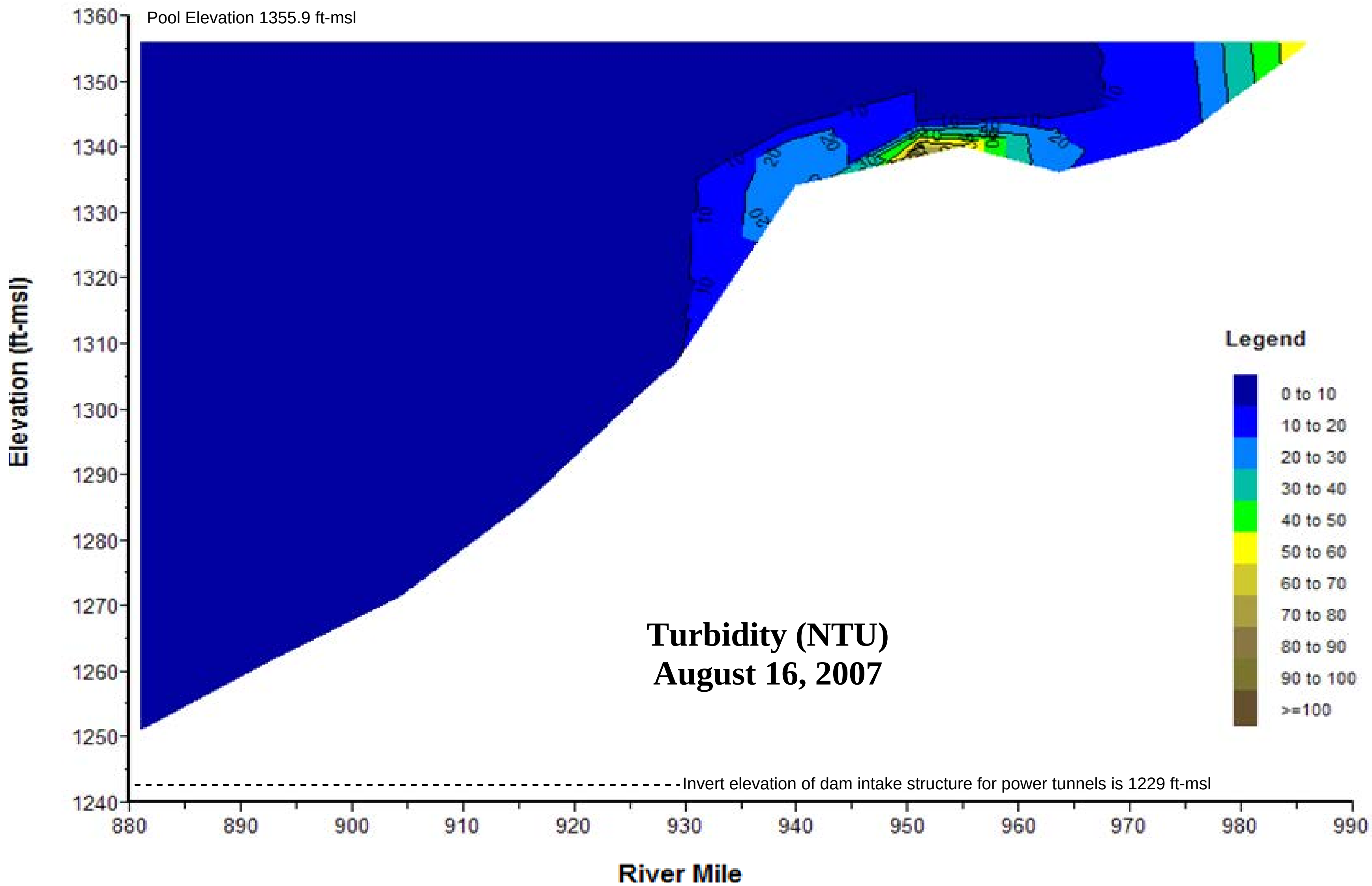


Plate 225. Longitudinal turbidity (NTU) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on August 16, 2007.

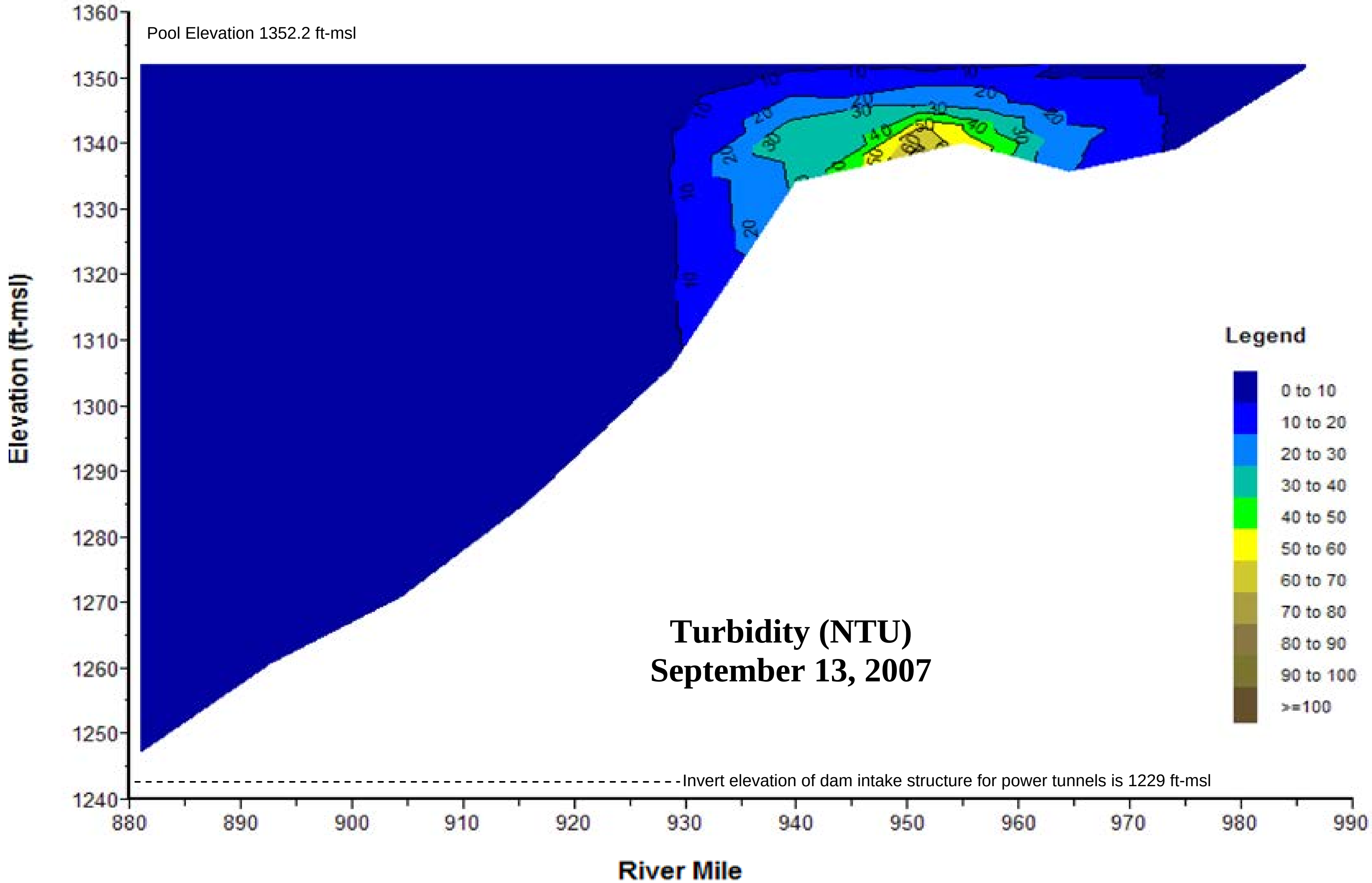


Plate 226. Longitudinal turbidity (NTU) contour plot of Fort Randall Reservoir based on depth-profile dissolved oxygen concentrations measured at sites FTRLK0880A, FTRLK0892DW, FTRLK0911DW, FTRLK0924DW, FTRLK0940DW, FTRLK0955DW, FTRLK0968DW, and BBDPP1 on September 13, 2007.

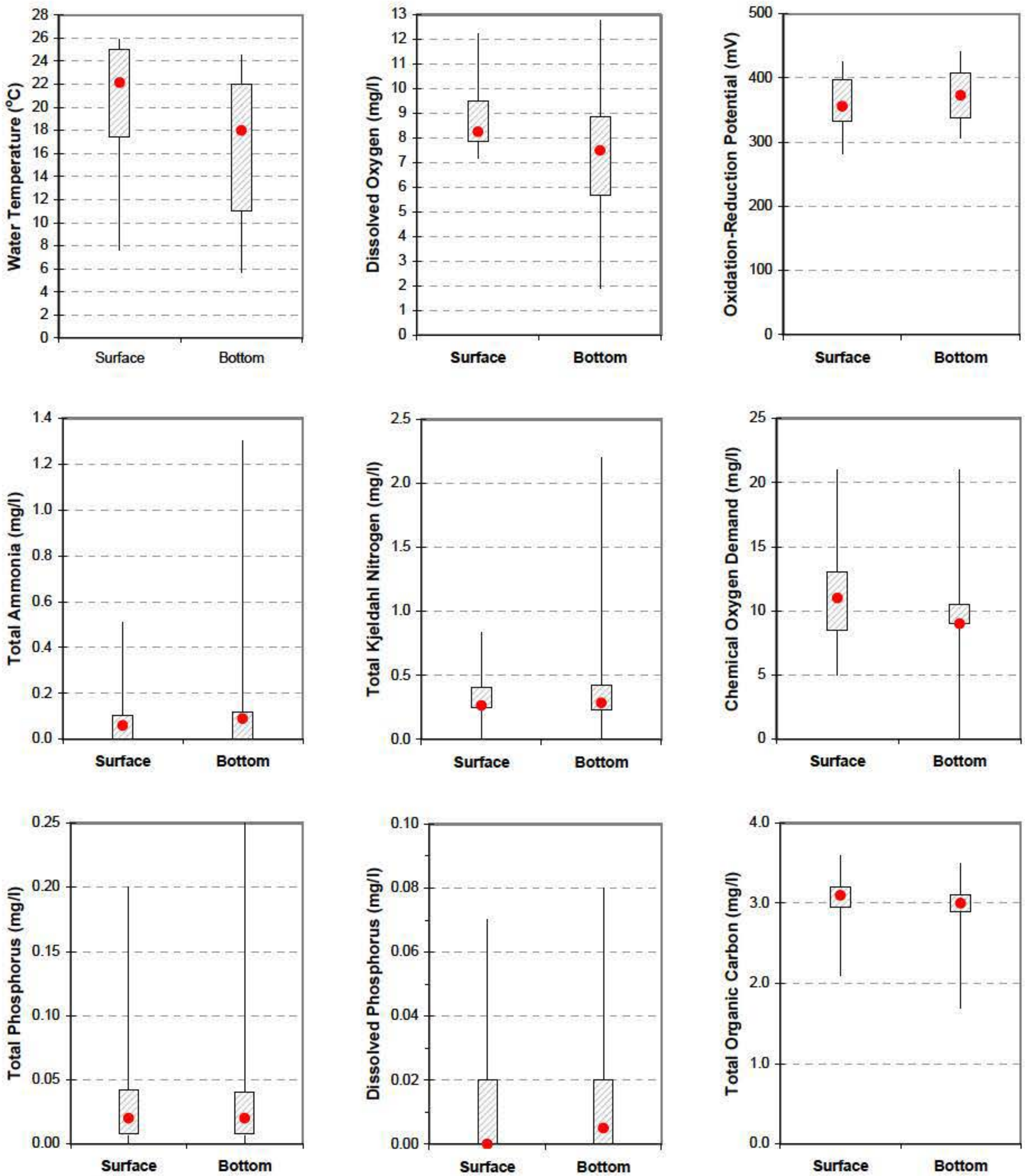


Plate 227. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measured in Fort Randall Reservoir at site FTRLK0880A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 228. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Randall Reservoir at site FTRLK0880A during the period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	4,925,542	3	0.83	0	-----	0	-----	1	0.09	2	0.08	0	-----	0	-----	0.76
Jul 2004	832,108	0	-----	0	-----	0	-----	2	0.97	2	0.03	0	-----	0	-----	0.79
Aug 2004	75,169,830	6	0.62	3	0.01	0	-----	2	0.16	2	<0.01	2	0.20	1	0.01	1.92
May 2005	1,277,161,733	12	0.97	6	0.02	0	-----	2	0.01	4	<0.01	0	-----	0	-----	1.60
Jun 2005	12,054,751	4	0.41	4	0.19	0	-----	1	0.30	3	0.10	0	-----	0	-----	1.84
Jul 2005	103,882,588	6	0 91	2	<0.01	1	0.06	1	<0.01	3	0.02	0	-----	0	-----	1.43
Aug 2005	131,927,592	5	0.77	4	0.07	1	<0.01	2	0.09	0	-----	1	0.04	1	0.04	1.57
Sep 2005	20,963,108	3	0.15	1	0.01	0	-----	1	0.18	7	0.65	0	-----	0	-----	1.54
May 2006	1,511,202,710	6	1.00	2	<0.01	0	-----	1	<0.01	0	-----	0	-----	0	-----	0.73
Jun 2006	217,211,152	7	0.80	6	0.09	1	0.09	1	0.02	1	<0.01	0	-----	0	-----	1.44
Jul 2006	39,547,409	7	0.88	5	0.08	0	-----	1	0.02	3	0.02	0	-----	1	<0.01	1.44
Aug 2006	250,444,849	5	0.74	7	0.11	2	0.09	1	0.01	1	<0.01	1	0.03	1	0.03	1.57
Sep 2006	391,168,130	6	0.81	11	0.11	0	-----	1	0.02	3	0.01	1	0.03	1	0.01	1.88
May 2007	1,128,309,549	5	0.95	1	0.01	1	<0.01	1	0.02	0	-----	2	0.02	0	-----	1.10
Jun 2007	249,294,812	3	0 38	4	0.41	1	<0.01	1	0.21	0	-----	0	-----	0	-----	1.25
Jul 2007	101,717,269	8	0.61	8	0.15	0	-----	1	0.10	1	0.04	1	0.10	0	-----	1.83
Aug 2007	312,786,957	8	0 39	8	0.03	2	0.01	2	0.03	3	<0.01	1	0.54	1	<0.01	1.41
Sep 2007	228,330,946	7	0.70	11	0.13	0	-----	1	0.06	4	0.03	1	0.04	1	0.04	2.14
Mean*	**336,496,169**	**5.6**	**0.70**	**4.6**	**0.09**	**0.5**	**0.04**	**1.3**	**0.13**	**2.2**	**0.07**	**0.6**	**0.13**	**0.4**	**0.02**	**1.46**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 229. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Randall Reservoir at site FTRLK0911DW during 2006 and 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2006	69,931,419	5	0.44	7	0.36	2	0.08	1	0.04	1	0.06	1	0.03	0	-----	2.17
Jul 2006	98,641,374	2	0.34	5	0.13	0	-----	1	0.11	3	0.16	1	0.27	0	-----	1.86
Aug 2006	133,306,055	5	0.11	12	0.44	1	0.01	1	0.14	4	0.14	1	0.15	1	0.02	2.71
Sep 2006	83,623,877	10	0.32	15	0.43	0	-----	1	0.10	6	0.02	1	0.12	0	-----	2.59
Jun 2007	1,697,405,287	6	0.89	8	0.06	2	0.01	1	0.03	0	-----	1	0.01	0	-----	1.03
Jul 2007	529,054,652	6	0.04	7	0.02	1	0.01	1	0.02	3	0.88	1	0.04	0	----	0.73
Aug 2007	423,785,980	6	0 93	9	0.02	3	<0.01	2	0.01	3	<0.01	1	0.05	0	-----	1.09
Sep 2007	1,013,742,743	8	0.95	12	0.02	1	<0.01	2	<0.01	5	0.01	1	0.01	1	0.01	1.21
Mean*	**96,375,681**	**6.0**	**0.50**	**9.4**	**0.19**	**1.3**	**0.02**	**1.3**	**0.06**	**3.1**	**0.18**	**1.0**	**0.09**	**0.3**	**0.02**	**1.67**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 230. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Randall Reservoir at site FTRLK0940DW during 2006 and 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2006	518,893,912	11	0 92	9	0.05	0	-----	0	-----	1	0.03	0	-----	0	-----	1.06
Jul 2006	119,552,113	11	0.81	8	0.07	1	<0.01	0	-----	1	0.06	1	0.05	1	0.01	1.77
Aug 2006	320,031,467	12	0.72	15	0.12	1	0.01	1	<0.01	5	0.14	1	0.01	1	<0.01	2.86
Sep 2006	365,369,612	18	0.83	10	0.11	1	0.03	0	-----	0	-----	1	0.04	0	-----	2.77
Jun 2007	7,768,787,921	8	0 91	10	0.03	2	0.02	1	0.01	5	0.03	1	0.01	0	-----	0.80
Jul 2007	583,012,381	12	0.50	8	0.01	0	-----	1	0.01	3	0.47	1	0.01	0	-----	1.69
Aug 2007	210,296,968	10	0.48	11	0.22	1	<0.01	2	0.06	3	0.12	2	0.11	0	-----	2.72
Mean*	**330,961,776**	**11.7**	**0.74**	**10.1**	**0.09**	**0.9**	**0.01**	**0.7**	**0.02**	**2.6**	**0.14**	**1.0**	**0.04**	**0.3**	**<0.01**	**1.95**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 231. Total biovolume, number of genera present, and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected in Fort Randall Reservoir at site FTRLK0968DW during 2006 and 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2006	3,042,159,471	9	0.94	9	0.04	1	<0.01	1	<0.01	2	0.01	1	<0.01	0	-----	0.44
Jul 2006	235,103,339	7	0.24	6	0.72	1	<0.01	1	0.01	1	0.03	0	-----	1	<0.01	1.37
Aug 2006	842,613,801	19	0 91	14	0.04	2	<0.01	1	<0.01	6	0.03	1	0.01	1	<0.01	1.80
Sep 2006	270,757,940	17	0.80	11	0.14	1	0.01	1	<0.01	1	<0.01	1	0.04	2	0.01	2.42
Jun 2007	1,073,452,712	5	0.71	11	0.14	2	0.01	1	0.03	1	<0.01	1	0.11	0	-----	1.49
Jul 2007	405,005,185	14	0.42	6	0.02	1	<0.01	1	0.05	1	0.37	1	0.12	0	0.01	2.02
Aug 2007	162,100,006	11	0.55	6	0.03	2	0.02	1	0.01	3	<0.01	1	0.31	2	0.08	2.30
Sep 2007	121,850,078	8	0.73	6	0.03	1	<0.01	1	0.05	5	0.18	0	-----	0	-----	2.15
Mean*	**769,130,317**	**11.3**	**0.66**	**8.6**	**0.15**	**1.4**	**<0.01**	**1.0**	**0.02**	**2.5**	**0.08**	**0.8**	**0.10**	**0.8**	**0.02**	**1.75**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 232. Dominant taxa present in phytoplankton grab samples collected at the near-dam monitoring site (site FTRLK0880A) at Fort Randall Reservoir during the period 2004 through 2007.

Date	Division	Dominant Taxa*	Percent of Total Biovolume
June 2004	Bacillariophyta	*Fragilaria crotonensis*	0.81
July 2004	Cryptophyta	*Rhodomonas minuta*	0.60
	Cryptophyta	*Cryptomonas spp.*	0.37
August 2004	Bacillariophyta	*Tabellaria spp.*	0.23
	Pyrrophyta	*Ceratium hirundinella*	0.20
	Bacillariophyta	*Fragilaria crotonensis*	0.19
	Cryptophyta	*Cryptomonas spp.*	0.14
	Bacillariophyta	*Asterionella formossa*	0.14
May 2005	Bacillariophyta	*Fragilaria crotonensis*	0.47
	Bacillariophyta	*Asterionella formossa*	0.20
	Bacillariophyta	*Stephanodiscus spp.*	0.12
	Bacillariophyta	*Melosira varians*	0.11
June 2005	Cryptophyta	*Rhodomonas minuta*	0.30
	Bacillariophyta	*Stephanodiscus spp.*	0.22
	Bacillariophyta	*Cyclotella spp.*	0.17
July 2005	Bacillariophyta	*Fragilaria crotonensis*	0.45
	Bacillariophyta	*Synedra spp.*	0.33
August 2005	Bacillariophyta	*Cyclotella spp.*	0.48
	Bacillariophyta	*Synedra spp.*	0.20
September 2005	Cyanobacteria	*Planktolyngbya limnetica*	0.52
	Cyanobacteria	*Oscillatoria spp.*	0.12
	Cryptophyta	*Rhodomonas minuta*	0.11
May 2006	Bacillariophyta	*Fragilaria crotonensis*	0.51
	Bacillariophyta	*Asterionella formossa*	0.44
June 2006	Bacillariophyta	*Fragilaria crotonensis*	0.41
	Bacillariophyta	*Asterionella formossa*	0.18
July 2006	Bacillariophyta	*Asterionella formossa*	0.45
	Bacillariophyta	*Fragilaria crotonensis*	0.35
August 2006	Bacillariophyta	*Fragilaria crotonensis*	0.56
	Bacillariophyta	*Aulacoseira granulata*	0.16
September 2006	Bacillariophyta	*Aulacoseira granulata*	0.41
	Bacillariophyta	*Stephanodiscus niagarea*	0.20
	Bacillariophyta	*Fragilaria crotonensis*	0.10
May 2007	Bacillariophyta	*Fragilaria spp.*	0.69
	Bacillariophyta	*Aulacoseira spp.*	0.12
	Bacillariophyta	*Tabellaria flocculosa.*	0.10
June 2007	Chlorophyta	*Pyramichlamys spp.*	0.39
	Bacillariophyta	*Fragilaria spp.*	0.35
	Cryptophyta	*Rhodomonas spp.*	0.21
July 2007	Bacillariophyta	*Fragilaria spp.*	0.48
	Pyrrophyta	*Ceratium hirundinella*	0.10
August 2007	Pyrrophyta	*Ceratium hirundinella*	0.54
	Bacillariophyta	*Fragilaria capucina var. gracilis*	0.25
	Bacillariophyta	*Aulacoseira spp.*	0.11
September 2007	Bacillariophyta	*Stephanodiscus spp.*	0.31
	Bacillariophyta	*Aulacoseira spp.*	0.21
	Bacillariophyta	*Fragilaria spp.*	0.15

* Dominant taxa are genera or species (depending on identification level) that comprised more than 10% of the total sample biovolume.

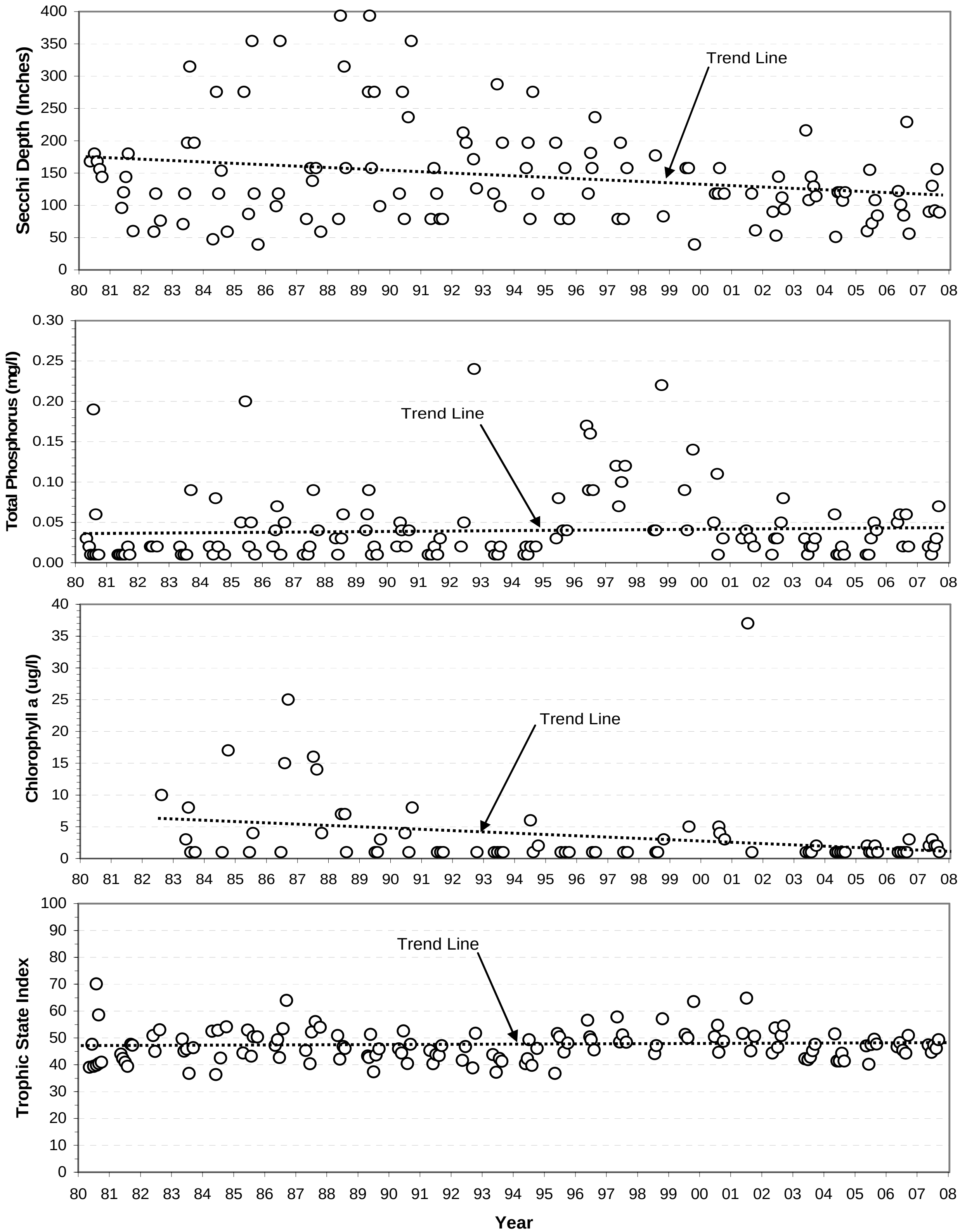


Plate 233. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Fort Randall Reservoir at the near-dam, ambient site (i.e., site FTRLK0880A) over the 28-year period of 1980 to 2007.

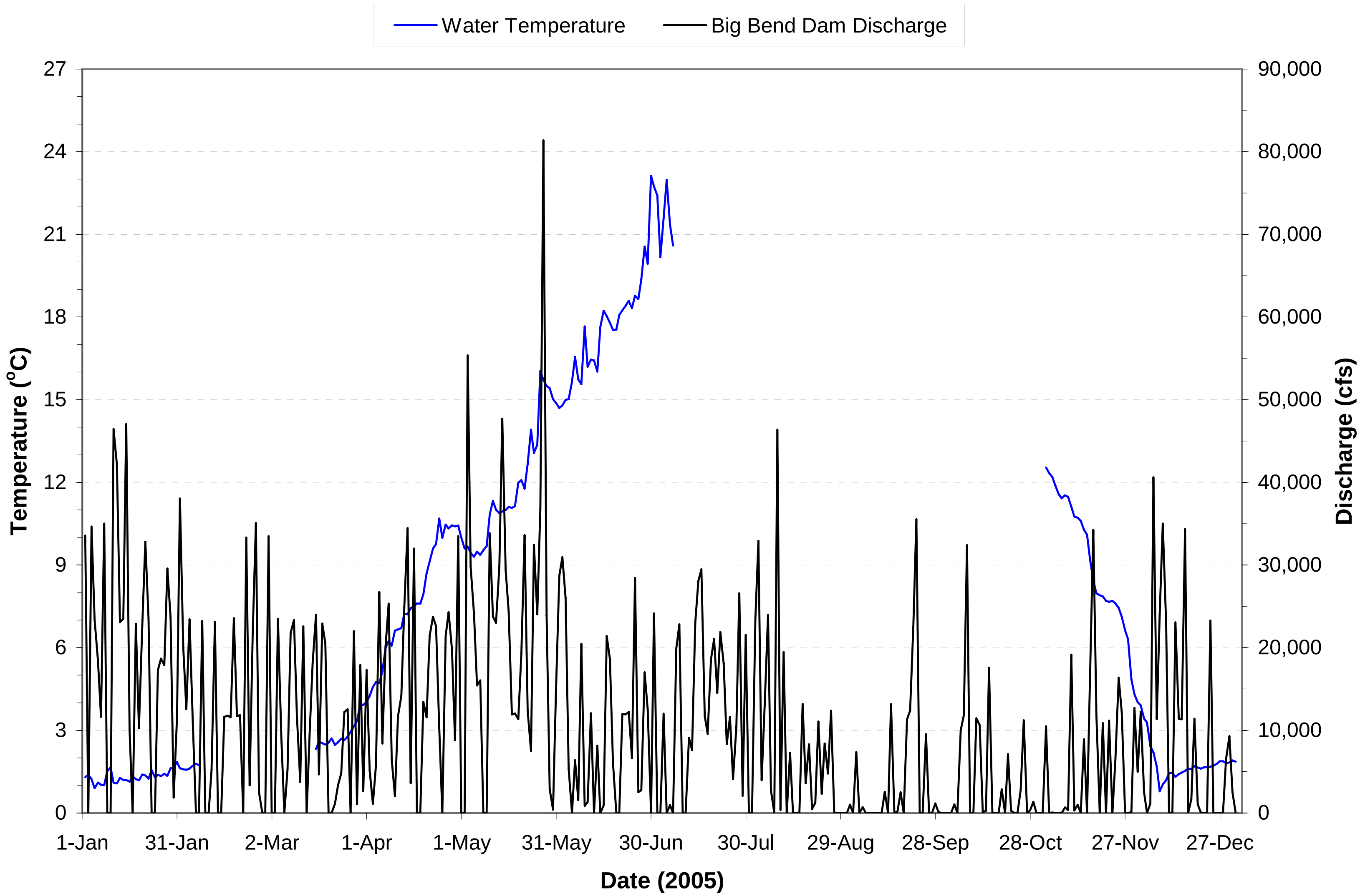


Plate 234. Mean daily water temperature and discharge of the Missouri River at Big Bend Dam (i.e., site BBDPP1) for 2005. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Big Bend Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

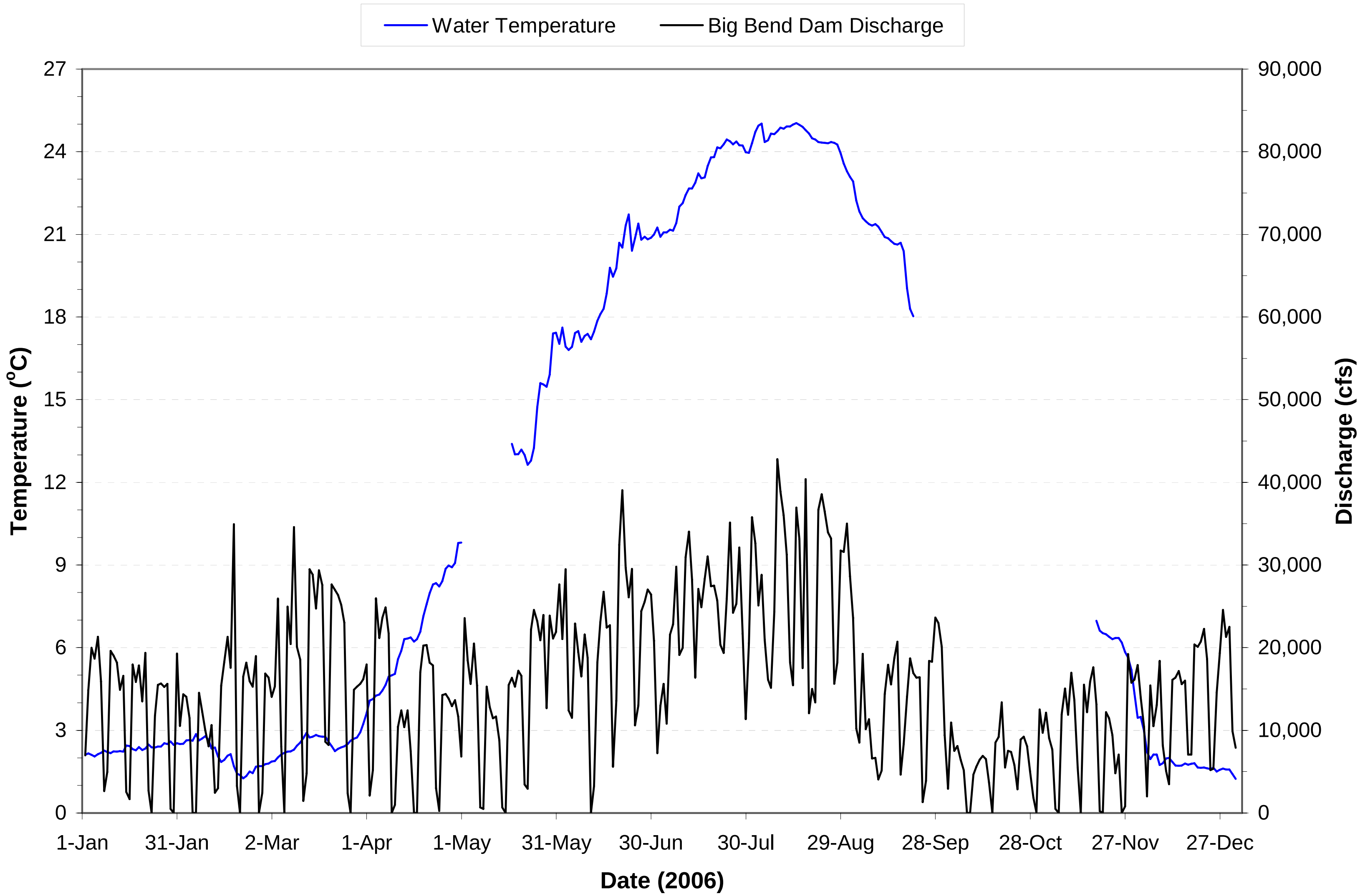


Plate 235. Mean daily water temperature and discharge of the Missouri River at Big Bend Dam (i.e., site BBDPP1) for 2006. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Big Bend Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

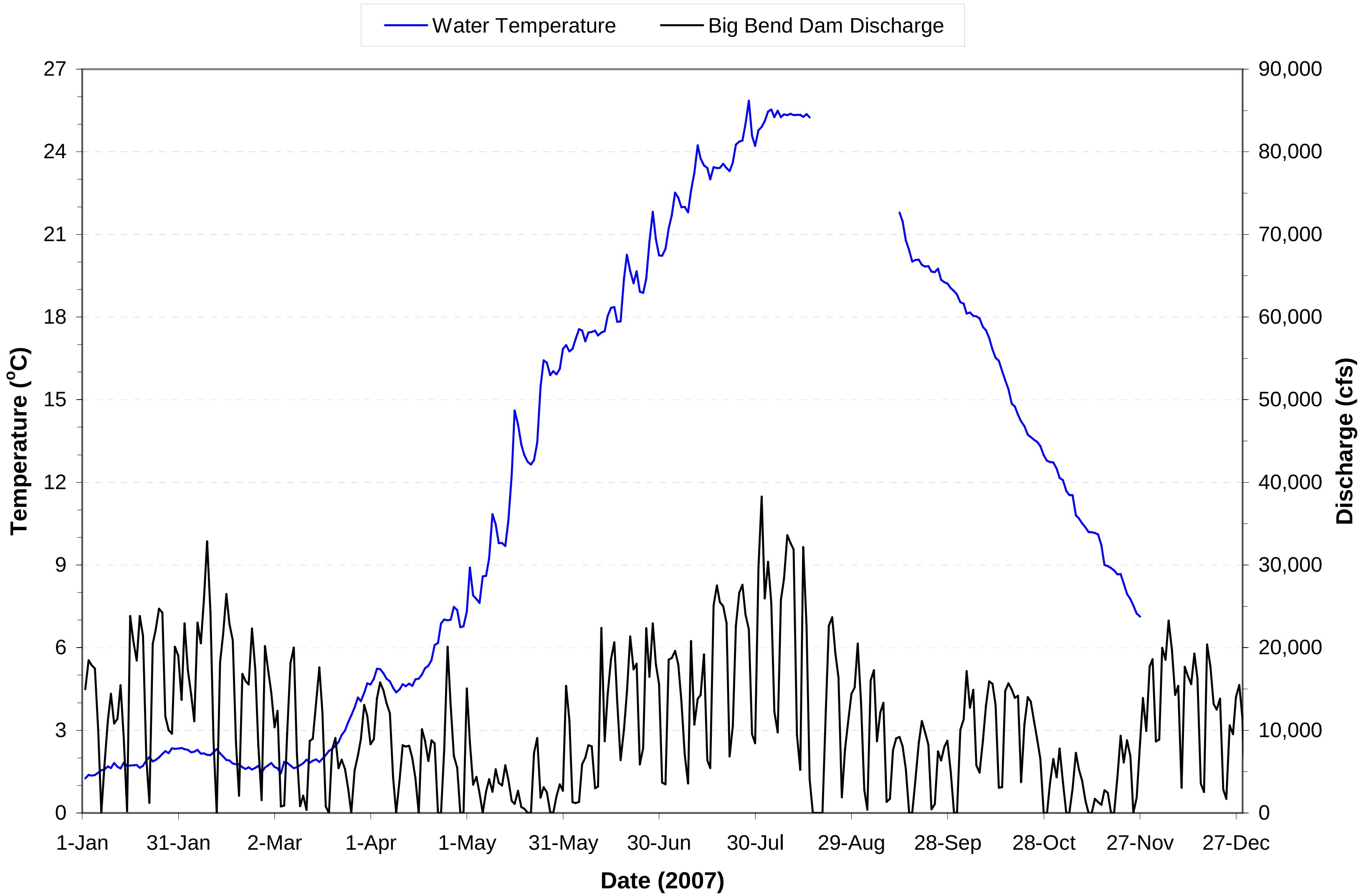


Plate 236. Mean daily water temperature and discharge of the Missouri River at Big Bend Dam (i.e., site BBDPP1) for 2007. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Big Bend Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

Plate 237. Summary of water quality conditions monitored on water discharged through Fort Randall Dam (i.e., site FTRPP1) during the 4-year period of 2004 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	38	22,265	21,800	0	41,200	-----	-----	-----
Water Temperature (C)	0.1	36	13.2	14.6	0.6	25.4	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	36	9.5	9.3	6.5	13.4	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	36	91.2	93.1	68.9	102.6	-----	-----	-----
Specific Conductance (umho/cm)	1	36	686	704	562	776	-----	-----	-----
pH (S.U.)	0.1	31	8.3	8.3	7.5	9.1	≥6.5 & ≤9.0	1	3%
Oxidation-Reduction Potential	1	17	377	364	273	458	-----	-----	-----
Alkalinity, Total (mg/l)	7	38	169	170	130	205	-----	-----	-----
Ammonia, Total (mg/l)	0.01	38	-----	0.04	n.d.	0.42	3.15 (1,2), 1.44 (1,3)	0	0%
Carbon, Total Organic (mg/l)	0.05	36	3.1	3.0	2.5	5.0	-----	-----	-----
Chloride (mg/l)	1	19	11	12	9	13	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	21	12	11	n.d.	22	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	38	169	170	130	205	1,750(4)	0	0%
Hardness, Total (mg/l)	0.4	2	224	224	211	238	-----	-----	-----
Iron, Dissolved (ug/l)	40	28	-----	n.d.	n.d.	50	-----	-----	-----
Iron, Total (ug/l)	40	29	119	80	n.d.	1,121	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	38	0.5	0.3	n.d.	3.6	-----	-----	-----
Manganese, Dissolved (ug/l)	1	28	-----	2	n.d.	14	-----	-----	-----
Manganese, Total (ug/l)	1	29	18	15	n.d.	47	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	38	-----	n.d.	n.d.	0.10	10(4)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	18	-----	n.d.	n.d.	0.07	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	38	-----	0.02	n.d.	0.25	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	36	-----	n.d.	n.d.	0.02	-----	-----	-----
Sulfate (mg/l)	1	38	208	210	117	232	875(4)	0	0%
Suspended Solids, Total (mg/l)	4	38	-----	n.d.	n.d.	26	158(2), 90(3)	0	0%
Antimony, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	0.6	6(4)	0	0%
Arsenic, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	1	340(2), 150(3), 50(4)	0	0%
Barium, Dissolved (ug/l)	5	1	31	31	31	31	1,000(4)	0	0%
Beryllium, Dissolved (ug/l)	2	3	-----	n.d.	n.d.	n.d.	4(4)	0	0%
Cadmium, Dissolved (ug/l)	0.2	6	-----	n.d.	n.d.	n.d.	11.2(2), 4.6(3), 5(4)	0	0%
Chromium, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	3,490(2), 167(3), 100(4)	0	0%
Copper, Dissolved (ug/l)	2	6	-----	3	n.d.	5	29.9(2), 18.6(3), 1,000(4)	0	0%
Lead, Dissolved (ug/l)	0.5	6	-----	n.d.	n.d.	n.d.	228(2), 8.9(3), 15(4)	0	0%
Mercury, Dissolved (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	-----	0	0%
Mercury, Total (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	1.7(2), 0.91(3), 0.05(4)	0	0%
Nickel, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	928(2), 103(3), 100(4)	0	0%
Selenium, Total (ug/l)	1	5	-----	n.d.	n.d.	2	20(2), 5(3), 50(4)	0	0%
Silver, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	n.d.	14.7	0	0%
Thallium, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	n.d.	0.47(4)	0	0%
Zinc, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	11	237(2,3), 9,100(4)	0	0%
Pesticide Scan (ug/l)***	0.05	4	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetect, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
(4) Human health criterion for surface waters.
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness of 224 mg/l.

*** The pesticide scan includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

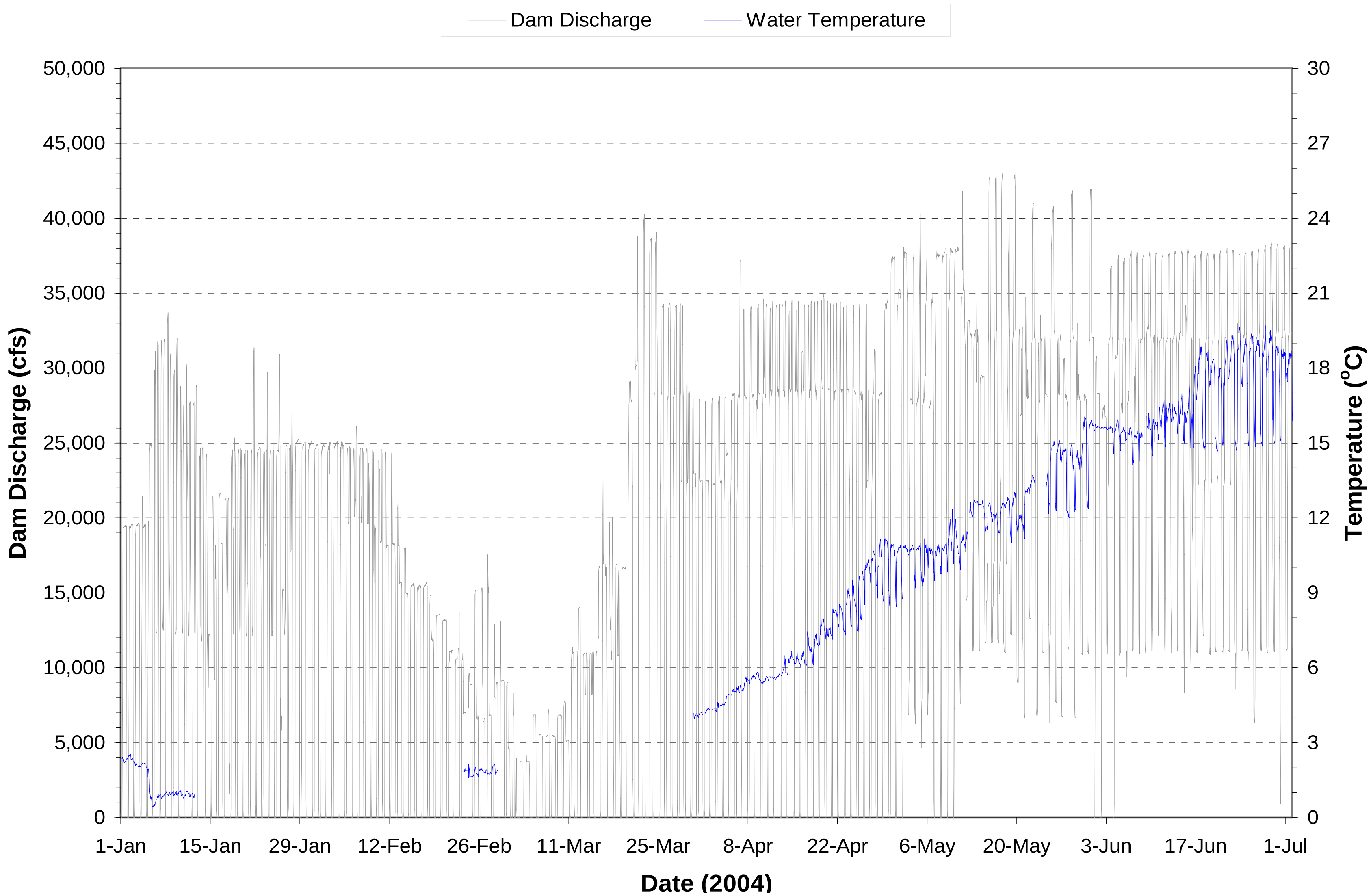


Plate 238. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

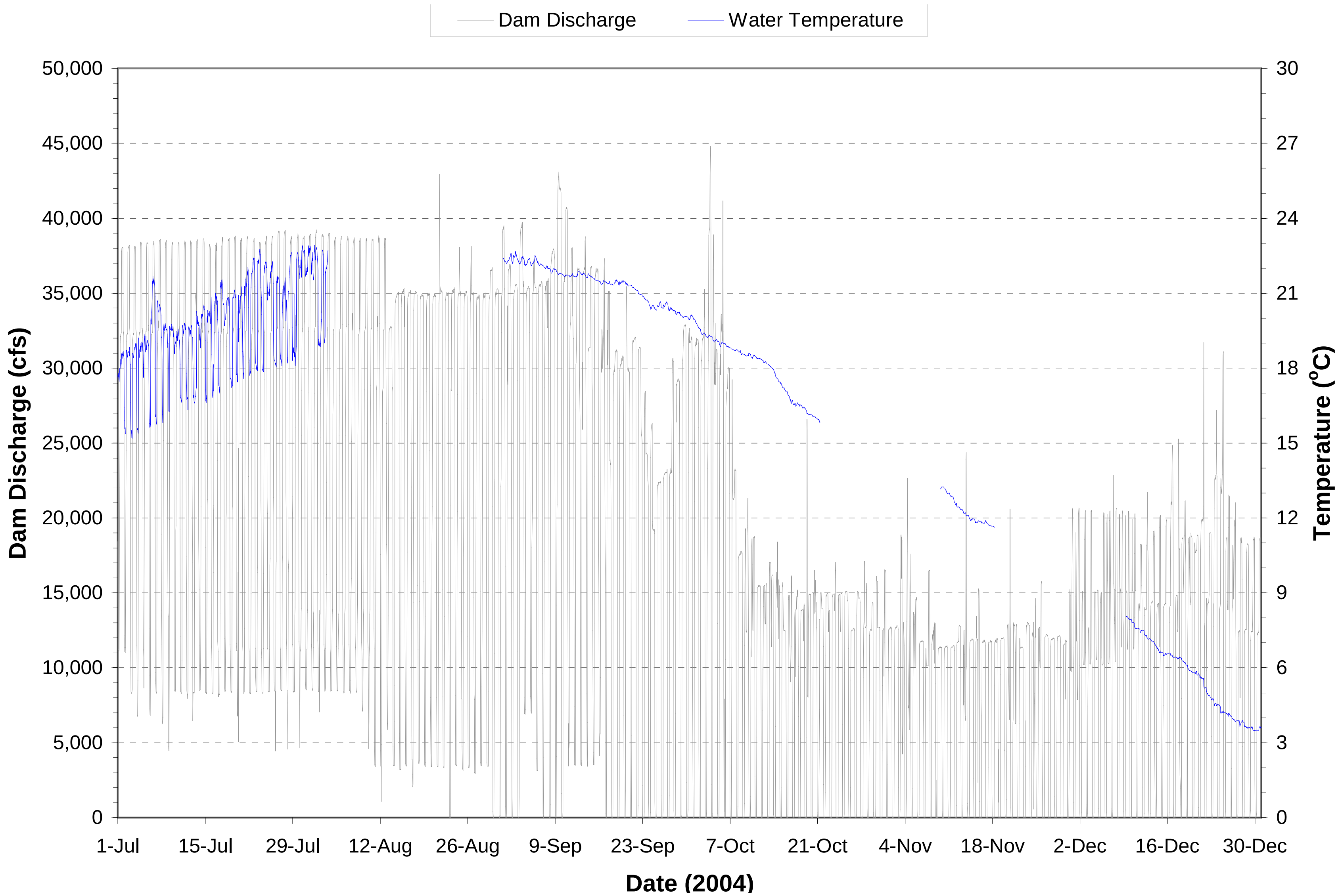


Plate 239. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

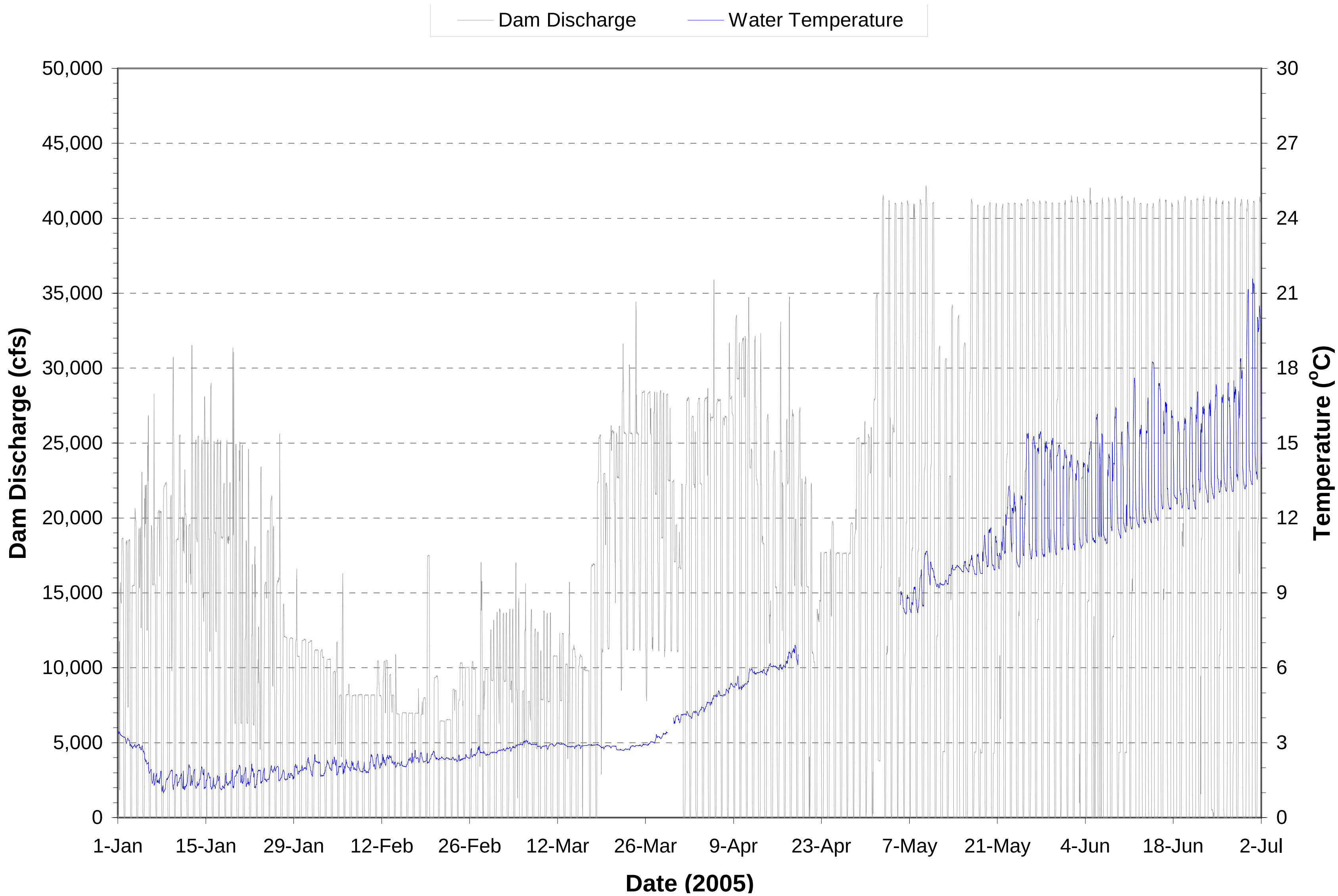


Plate 240. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

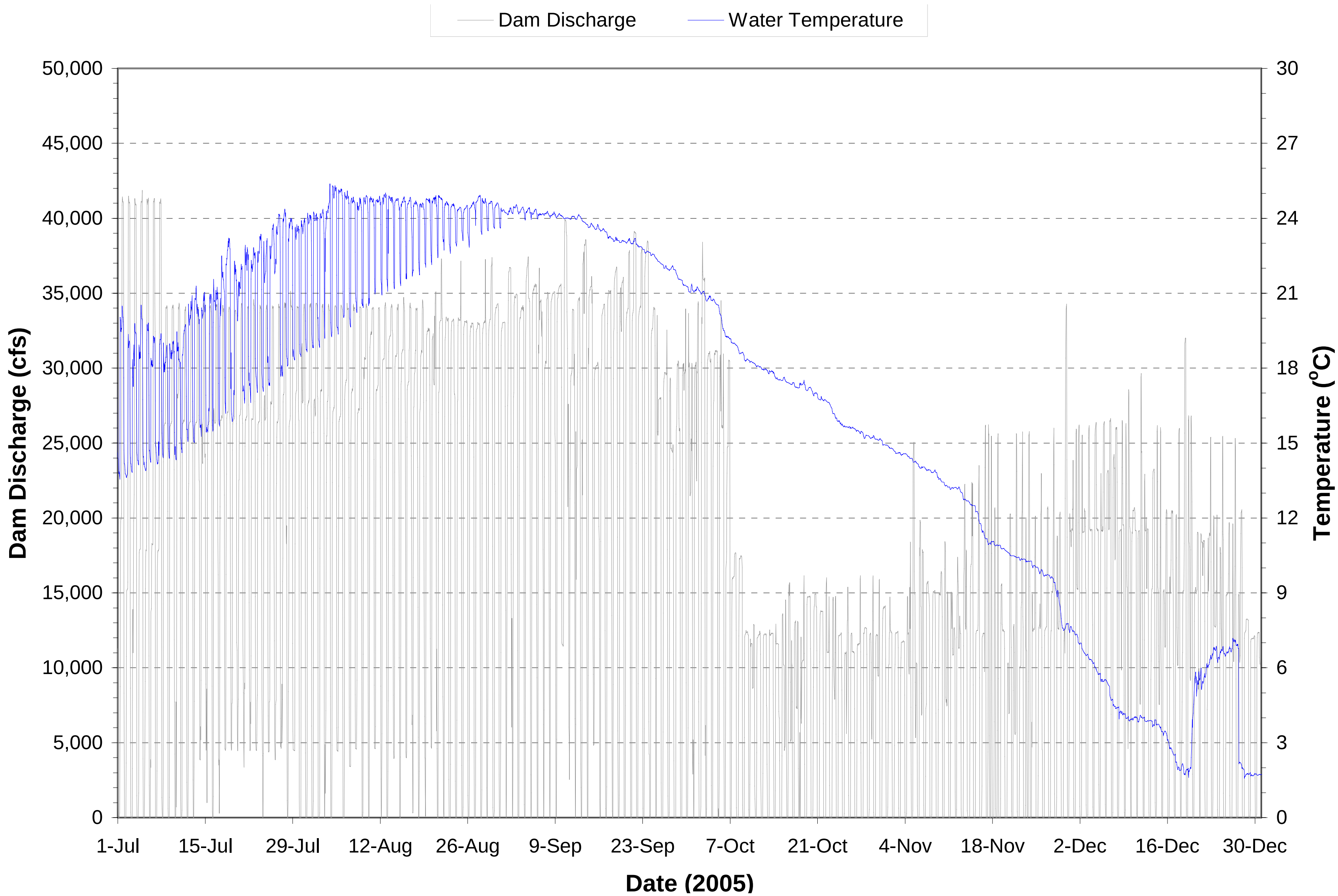


Plate 241. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2005.

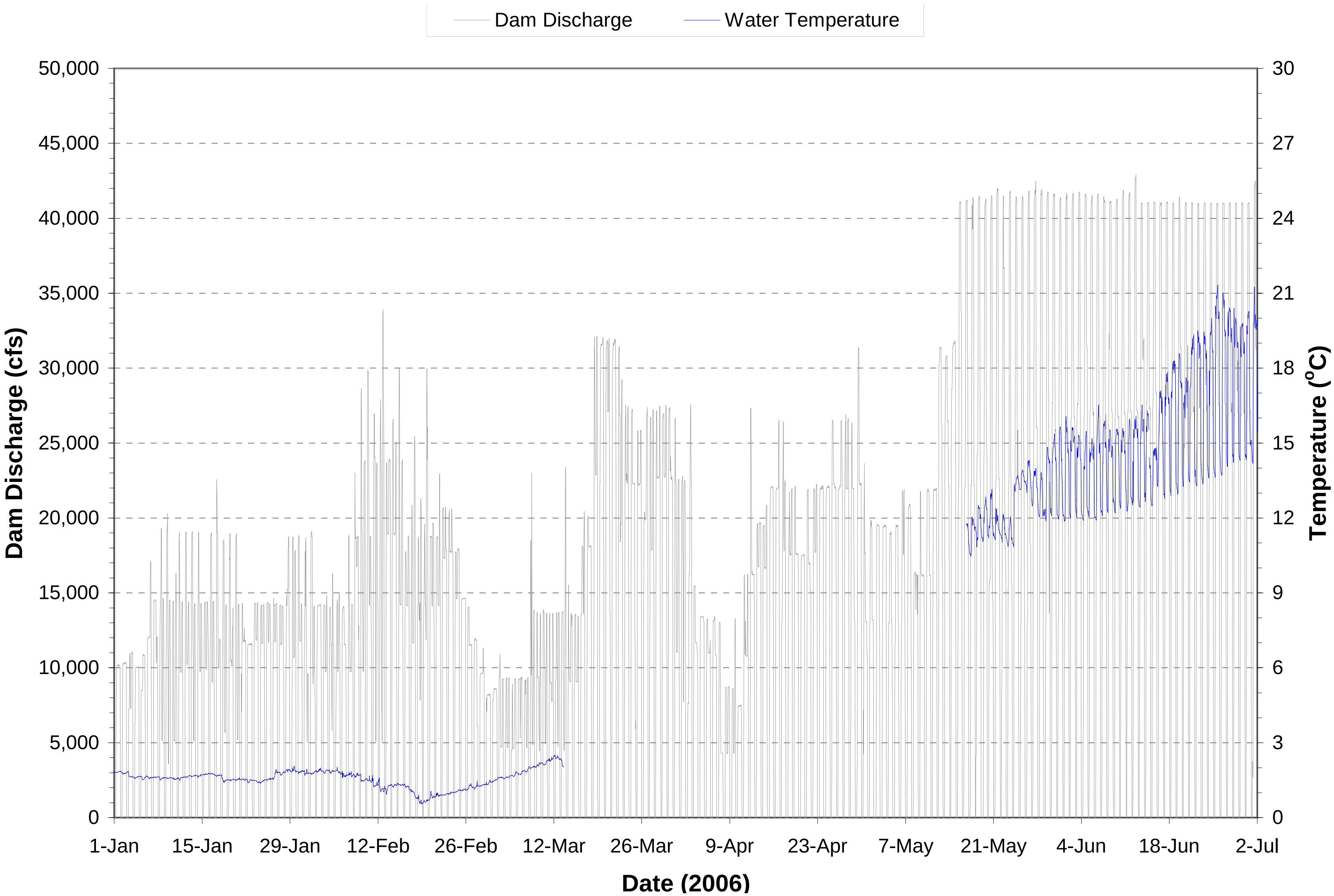


Plate 242. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

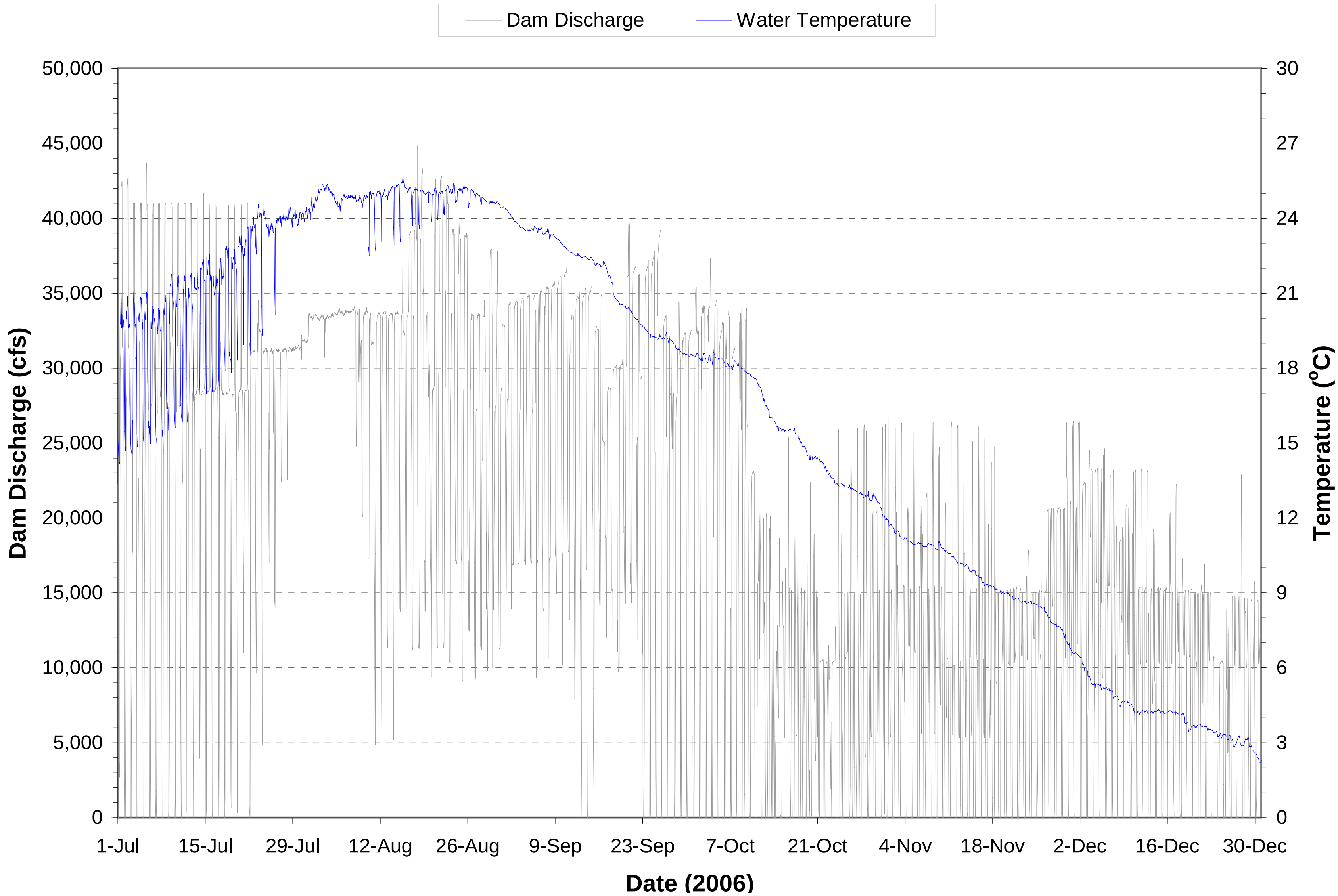


Plate 243. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2006.

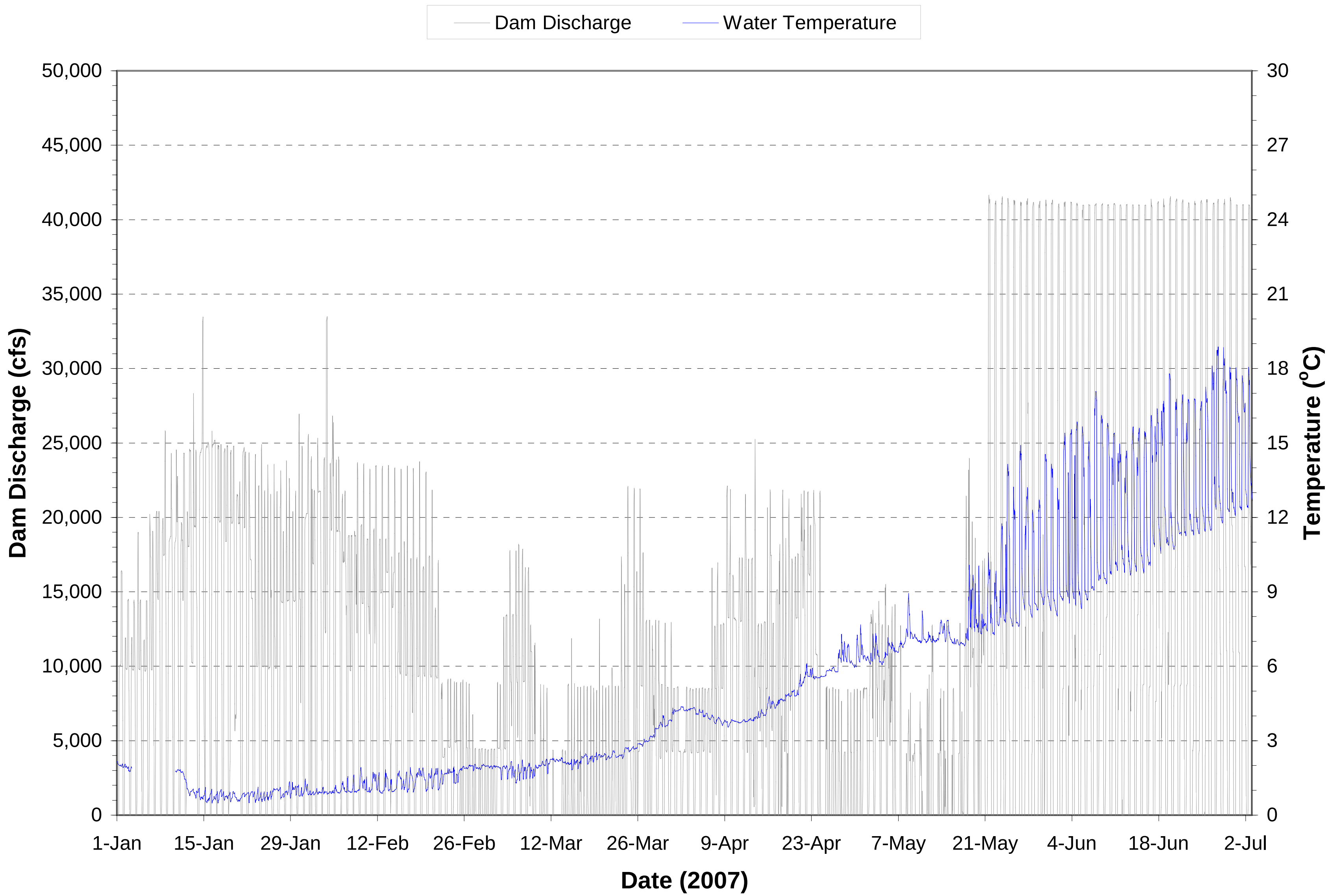


Plate 244. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

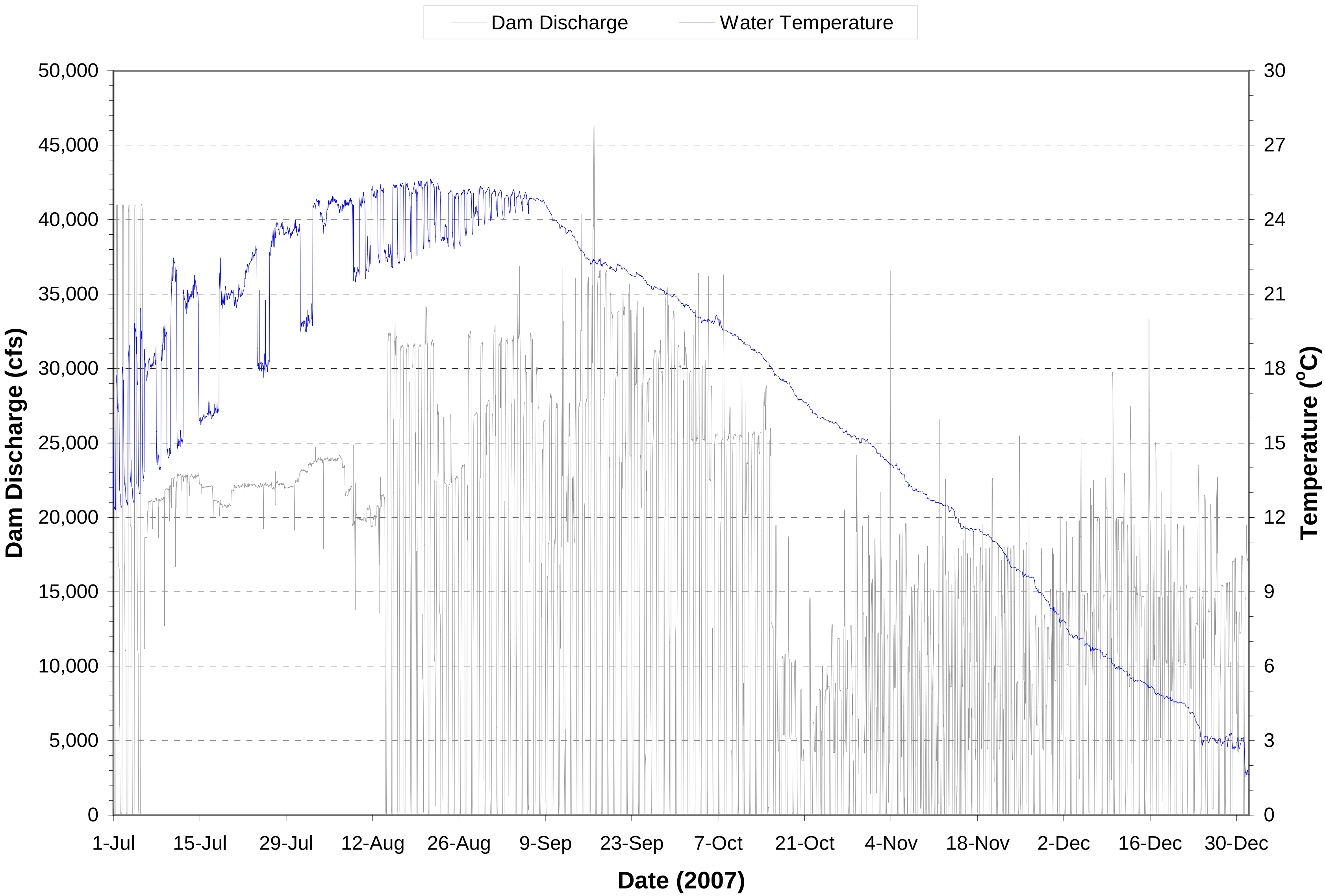


Plate 245. Hourly discharge and water temperature monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2007.

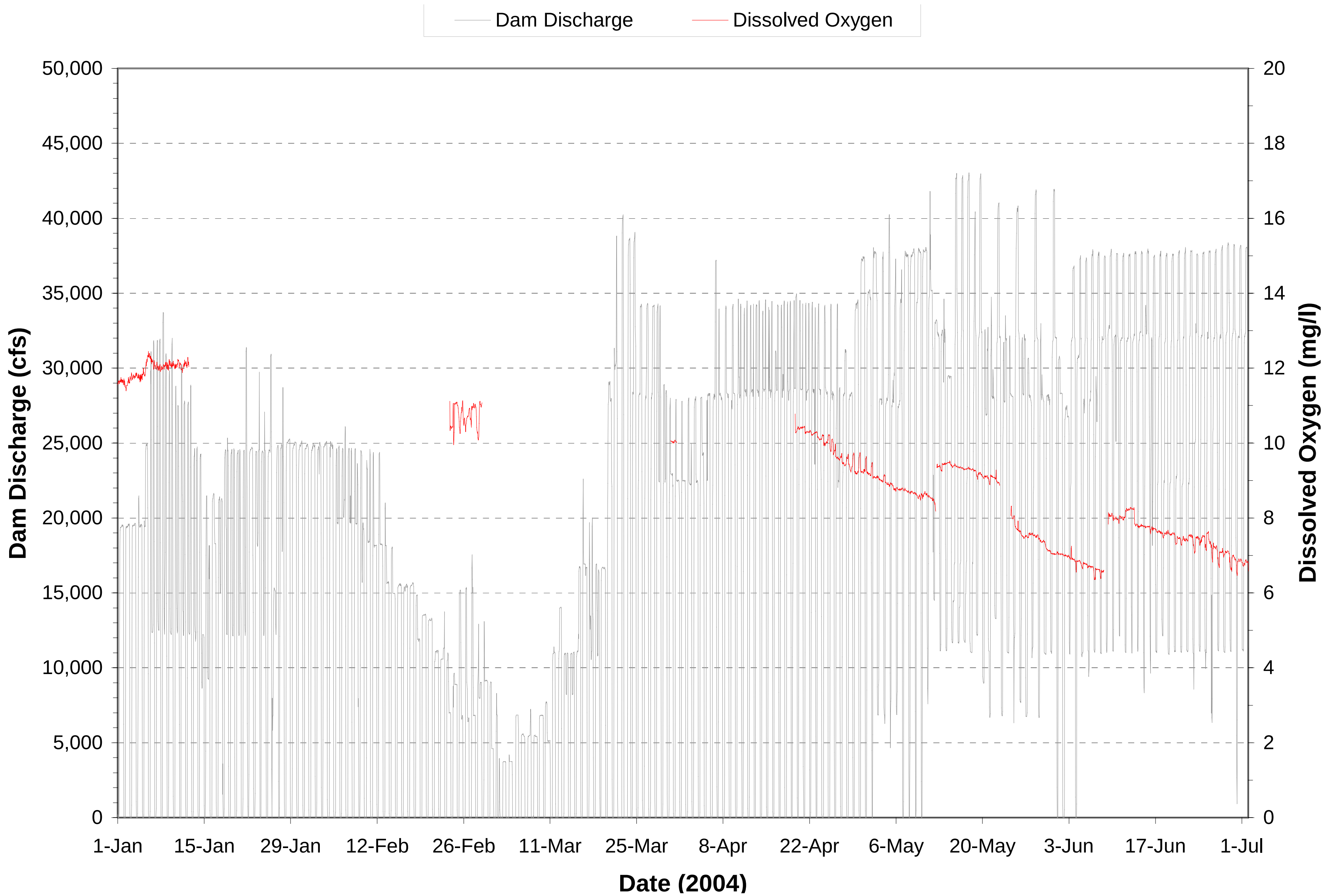


Plate 246. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

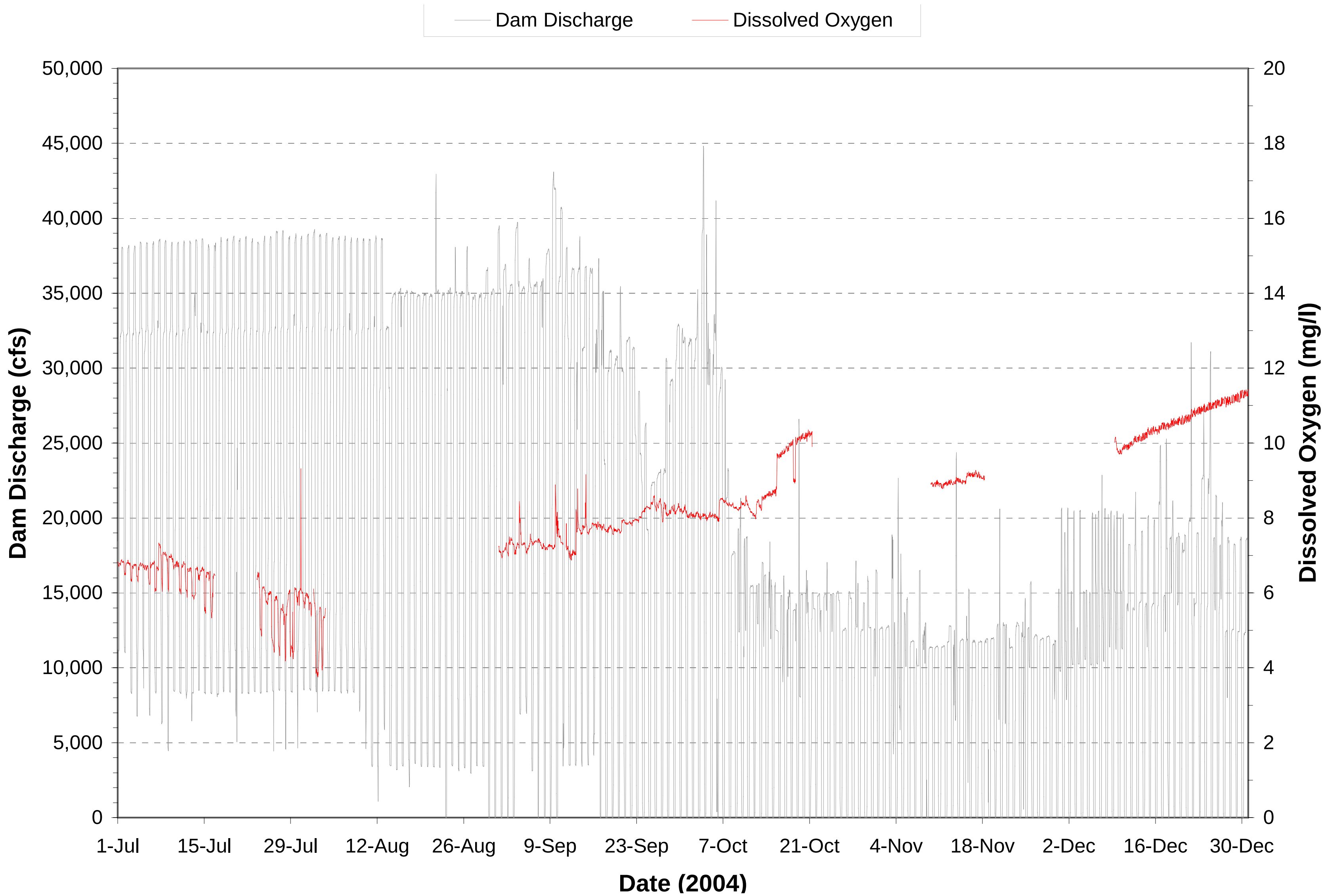


Plate 247. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

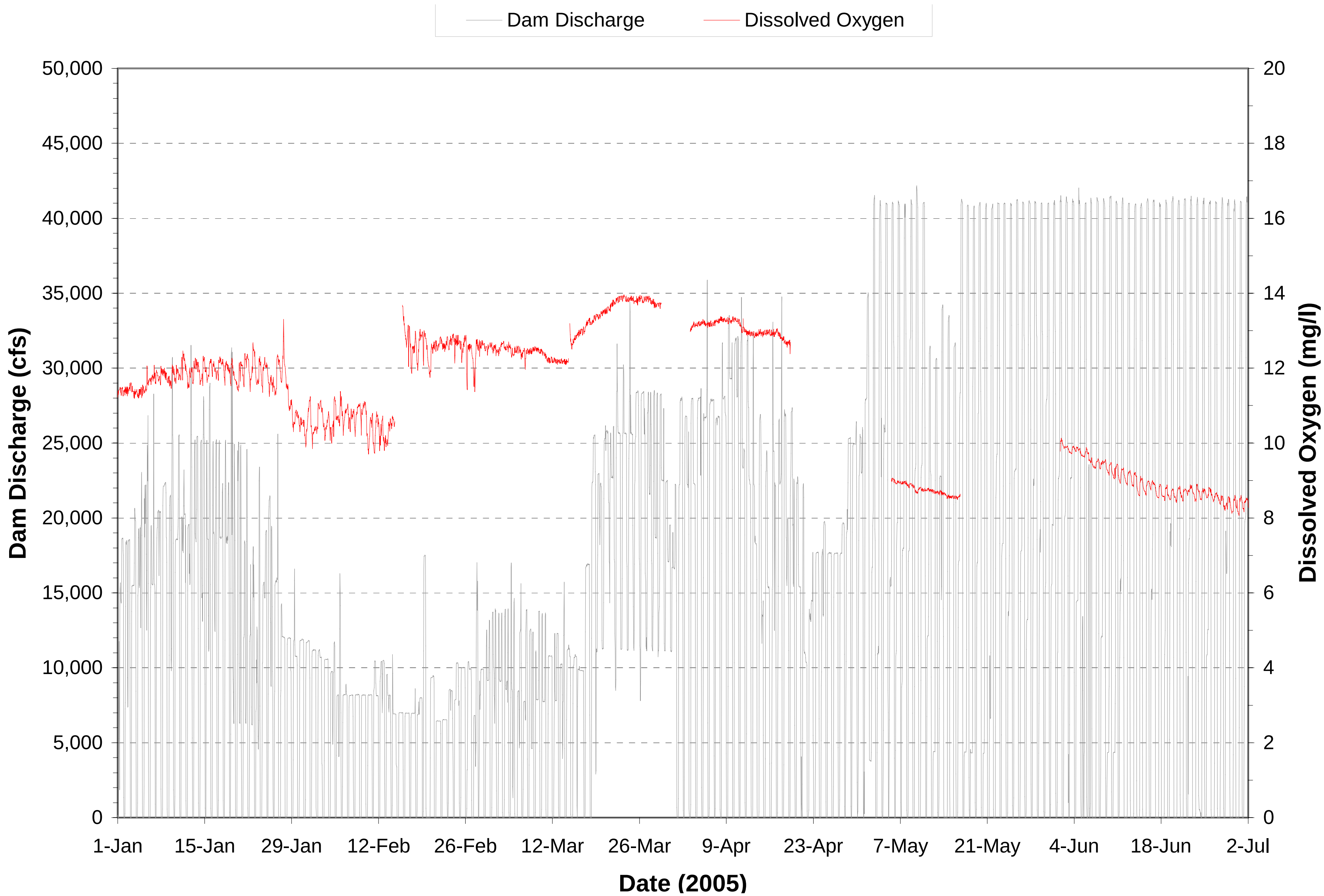


Plate 248. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

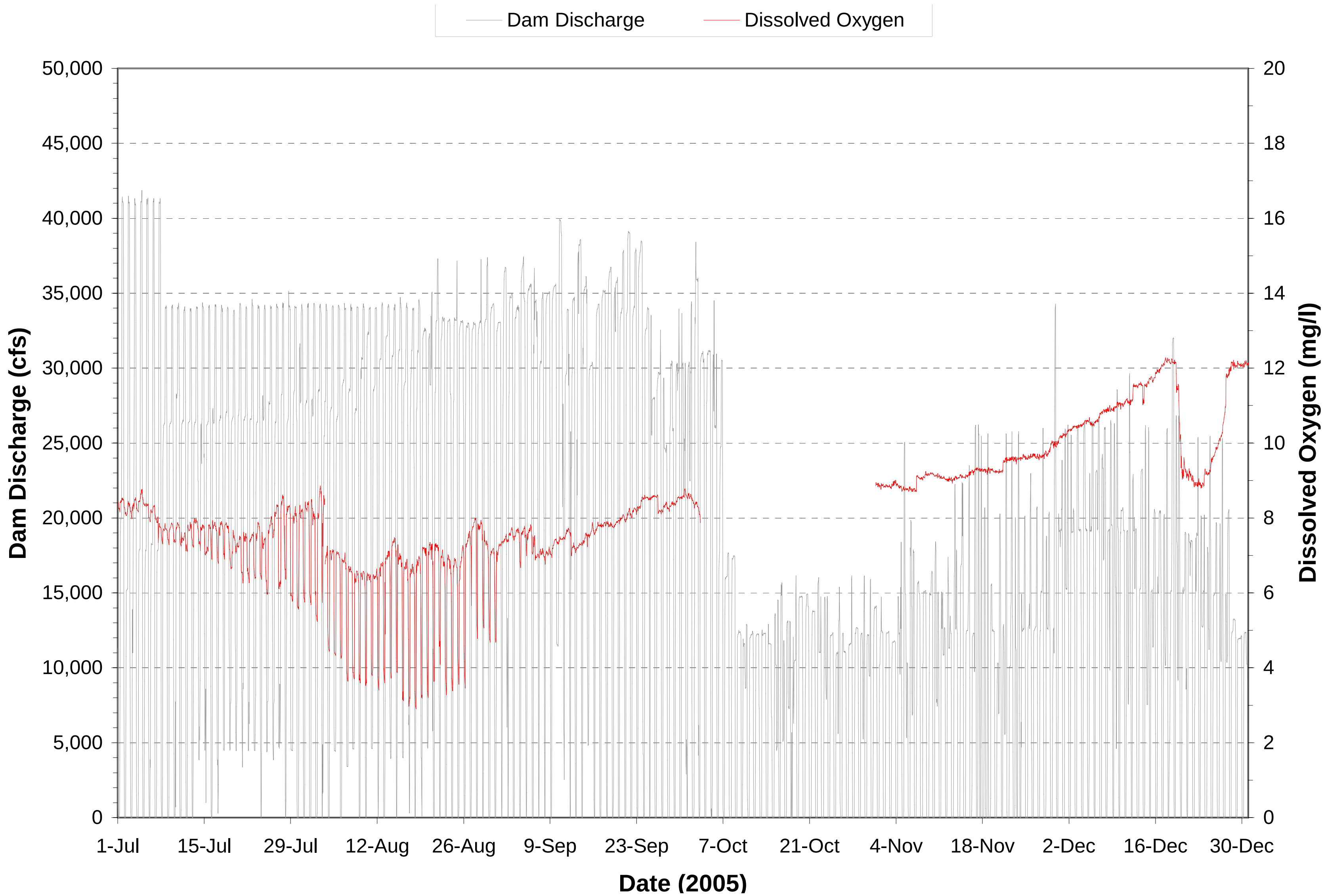


Plate 249. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

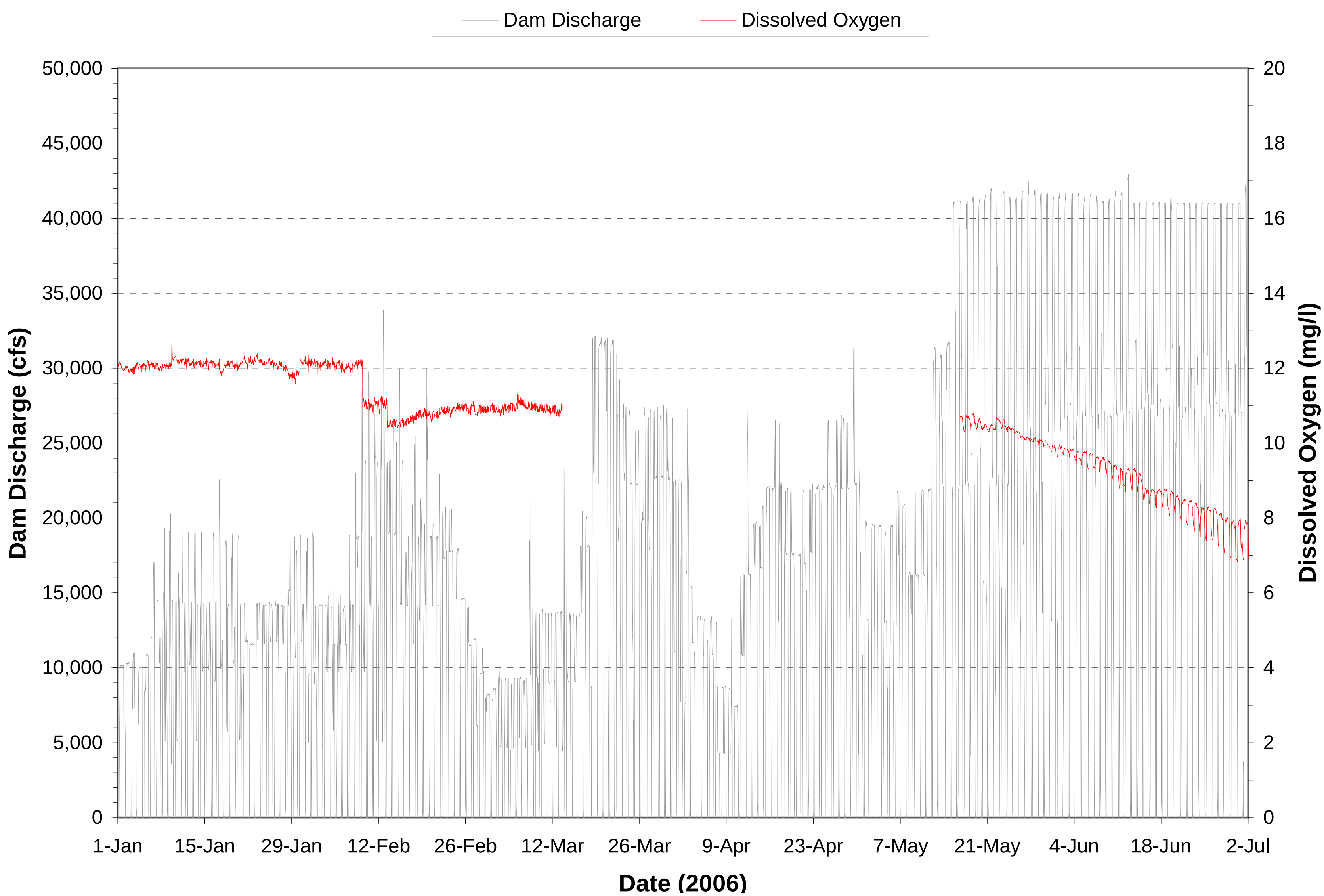


Plate 250. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

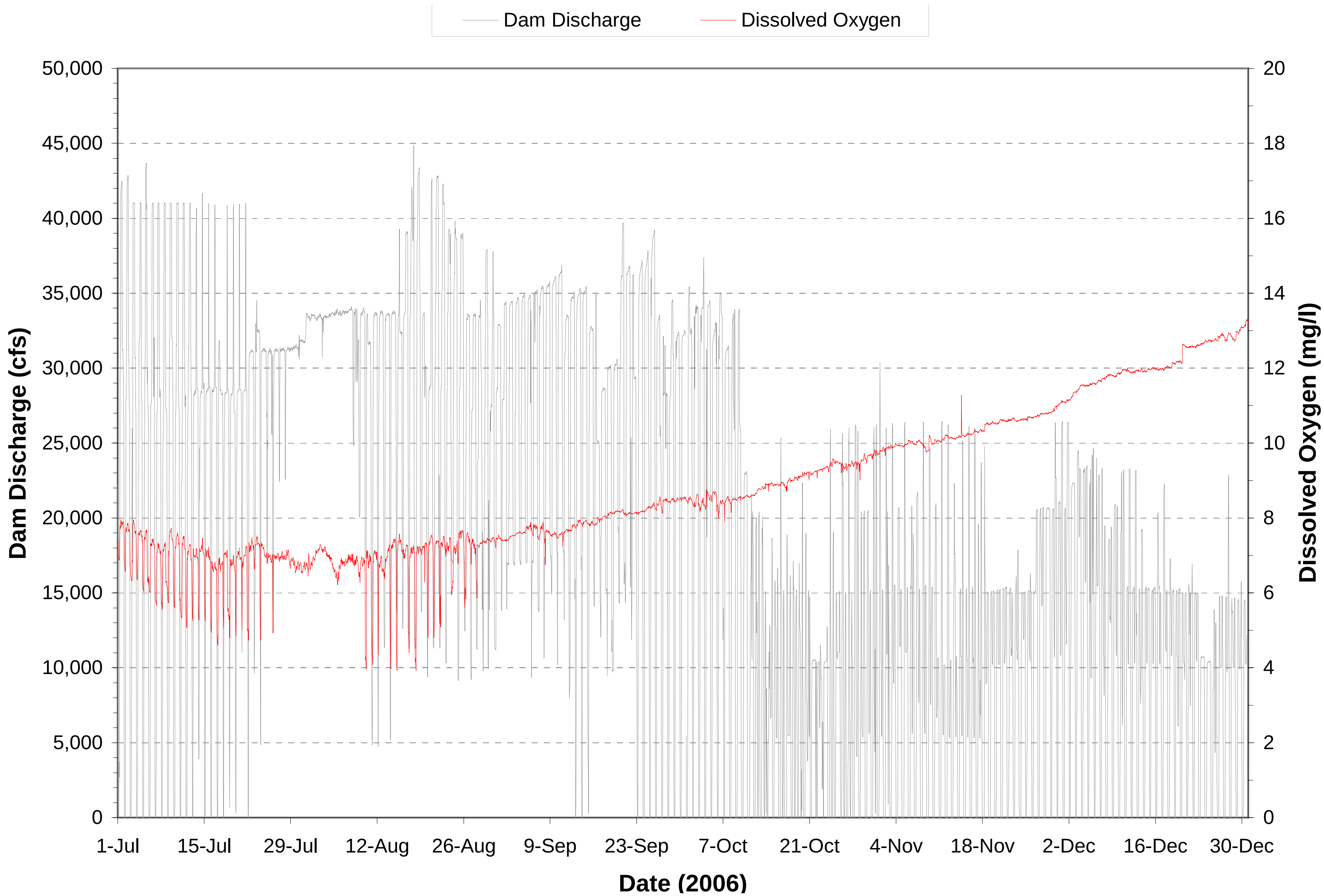


Plate 251. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2006.

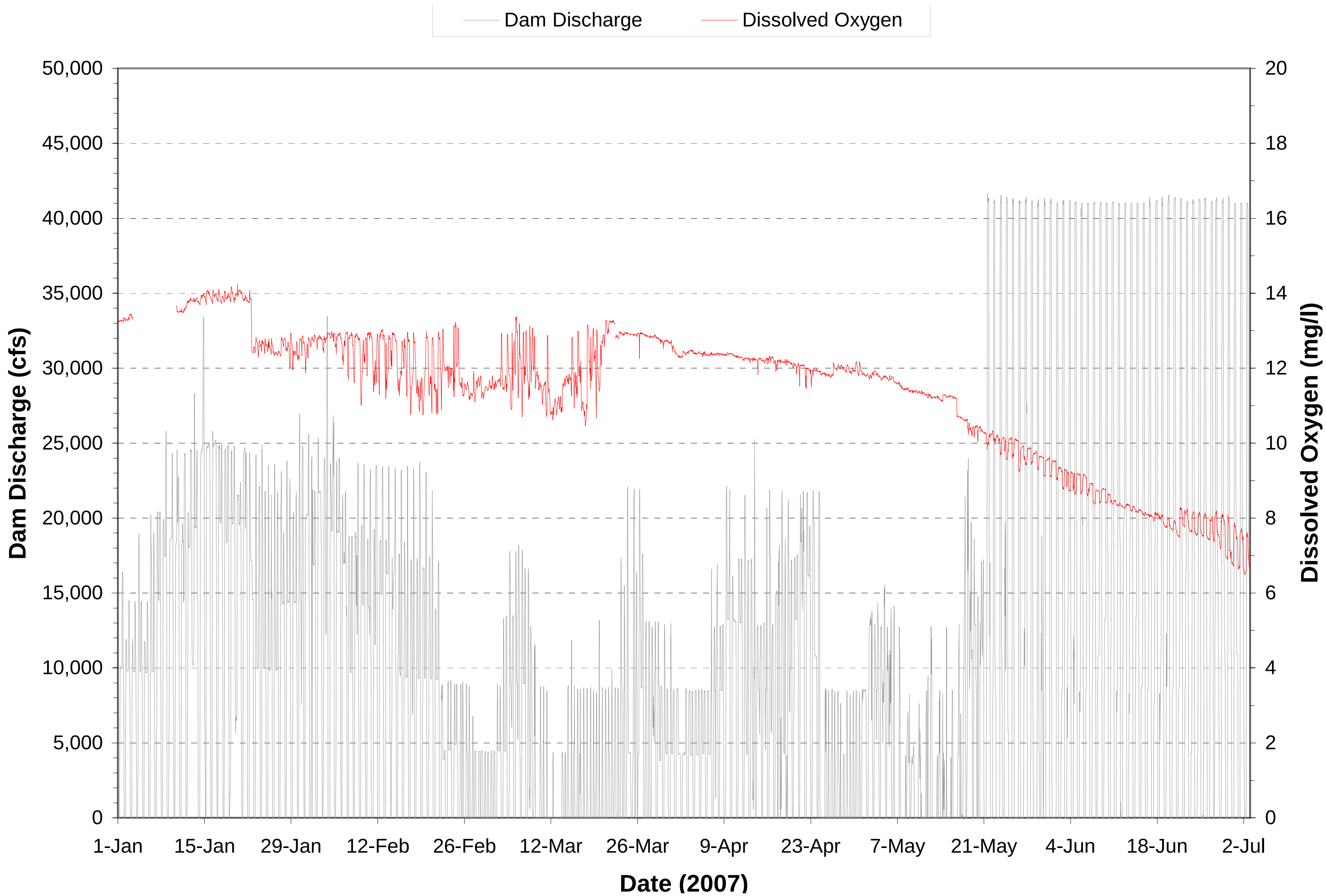


Plate 252. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period January through June 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

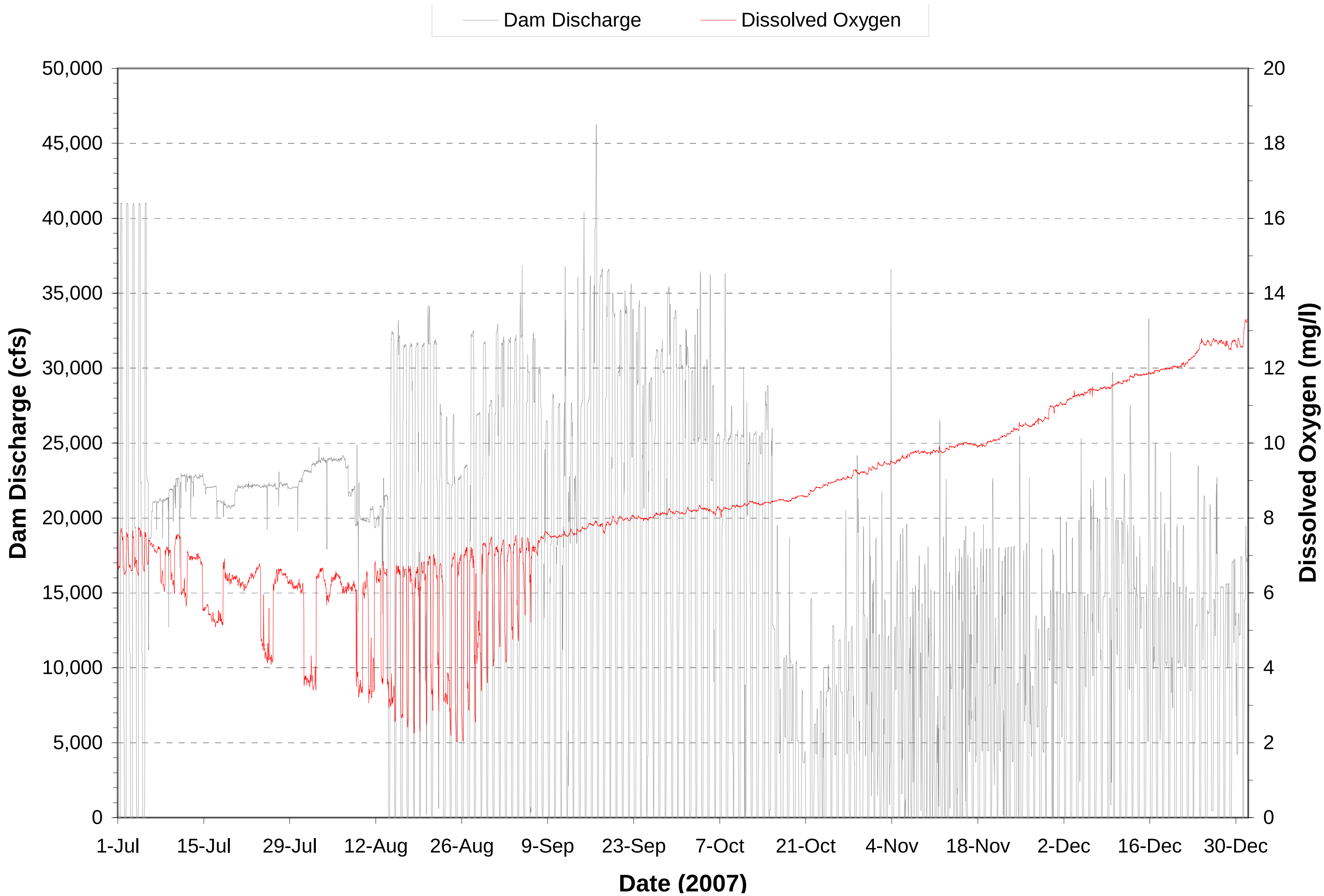


Plate 253. Hourly discharge and dissolved oxygen concentrations monitored at the Fort Randall powerplant on water discharged through the dam during the period July through December 2007.

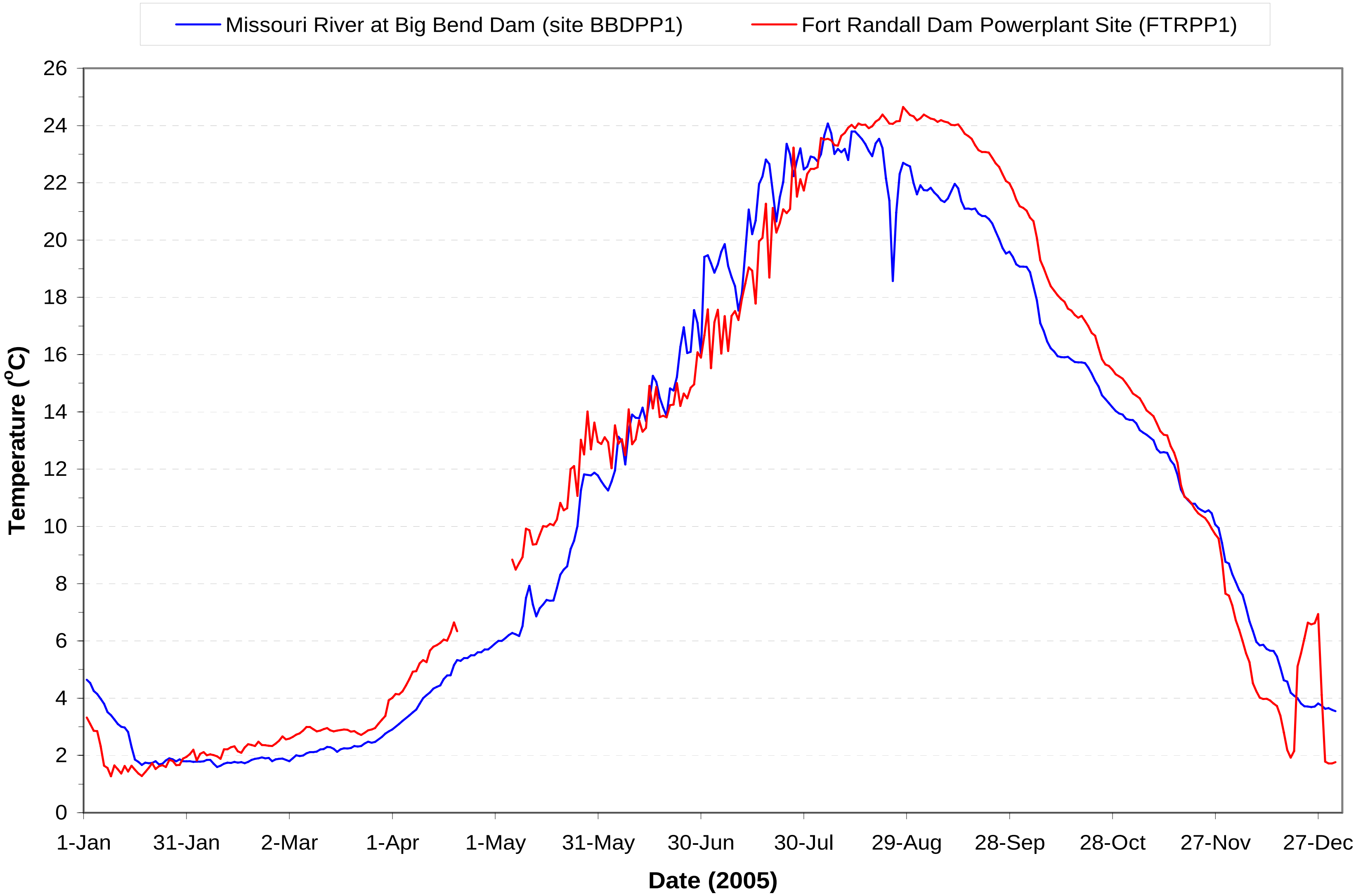


Plate 254. Mean daily water temperatures monitored at the Fort Randall Powerplant (i.e., site FTRPP1) and the Missouri River at Big Bend Dam (i.e., site BBDPP1) during 2005. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

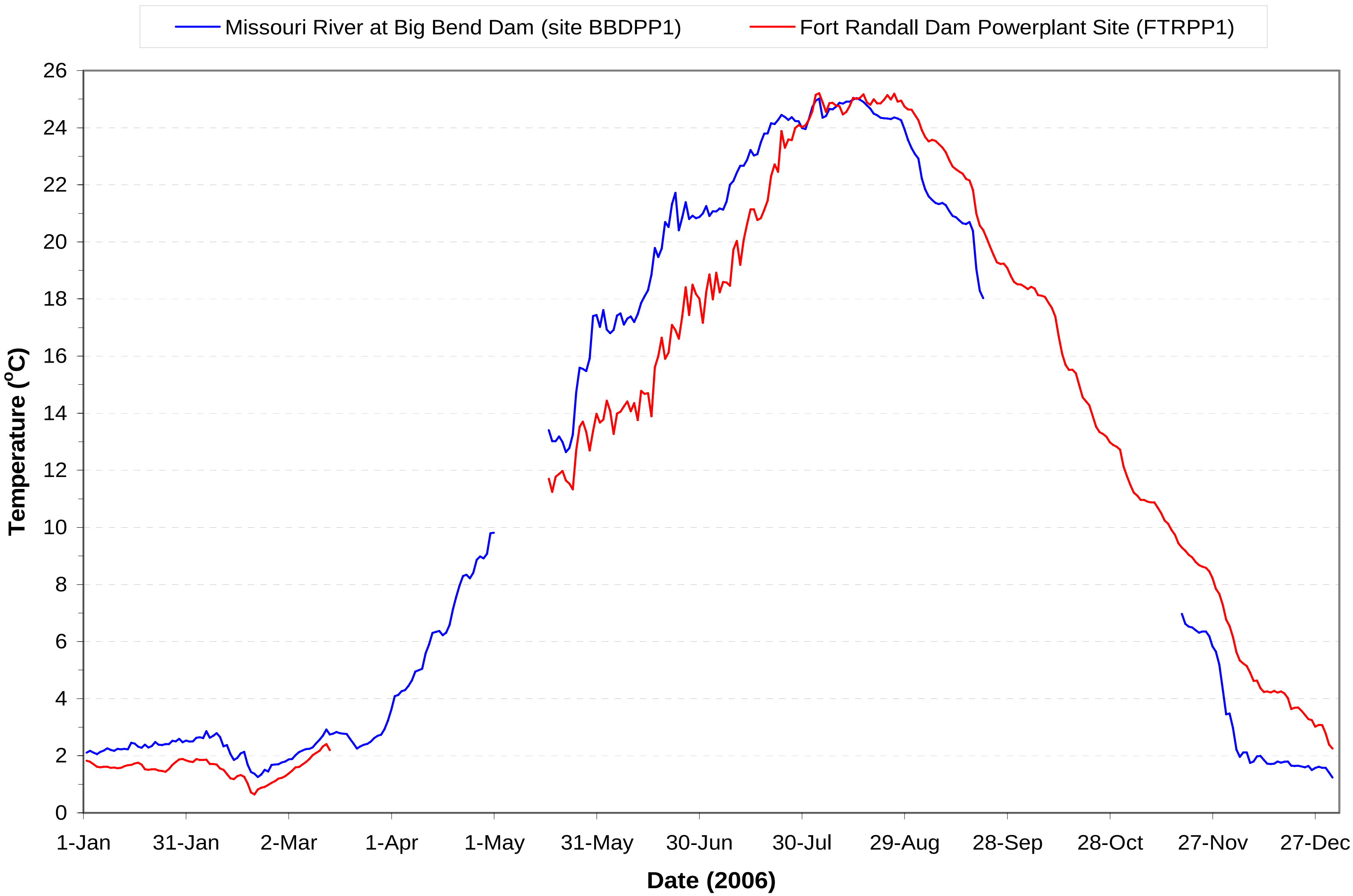


Plate 255. Mean daily water temperatures monitored at the Fort Randall Powerplant (i.e., site FTRPP1) and the Missouri River at Big Bend Dam (i.e., site BBDPP1) during 2006. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

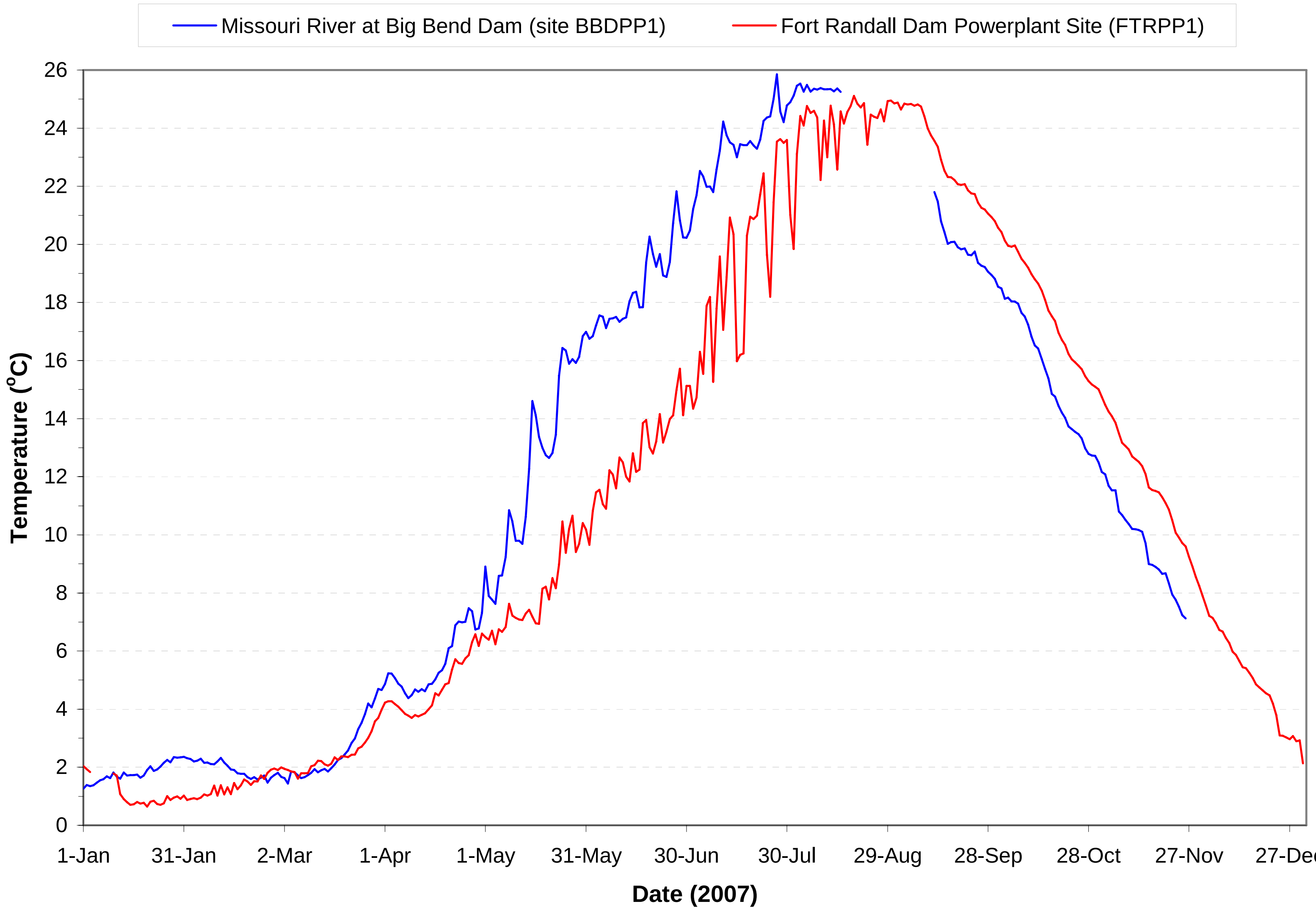


Plate 256. Mean daily water temperatures monitored at the Fort Randall Powerplant (i.e., site FTRPP1) and the Missouri River at Big Bend Dam (i.e., site BBDPP1) during 2007. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

Plate 257. Summary of water quality conditions monitored in the Missouri River at the Fort Randall Dam tailwaters (i.e., site FTRRRTW1) during the 5-year period of 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	83	23,180	24,500	4,000	42,400	-----	-----	-----
Water Temperature (C)	0.1	84	14.0	14.1	-0.1	26.2	27.0	0	0%
Dissolved Oxygen (mg/l)	0.1	84	9.7	9.3	4.9	16.9	≥ 5.0	1	1%
Dissolved Oxygen (% Sat.)	0.1	84	93.7	95.9	57.6	117.4	-----	-----	-----
Specific Conductance (umho/cm)	1	84	691	700	535	803	-----	-----	-----
pH (S.U.)	0.1	83	8.3	8.3	6.8	8.7	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential	1	29	398	400	322	516	-----	-----	-----
Alkalinity, Total (mg/l)	7	83	173	172	130	223	-----	-----	-----
Ammonia, Total (mg/l)	0.01	82	-----	0.07	n.d.	0.62	3.15 (1,2), 1.44 (1,3)	0	0%
Carbon, Total Organic (mg/l)	0.05	79	3.2	3.1	1.6	5.5	-----	-----	-----
Chloride (mg/l)	1	83	11	10	5	31	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	83	8	9	n.d.	18	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	35	505	480	442	840	1,750(4)	0	0%
Hardness, Total (mg/l)	0.4	14	228	234	186	242	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	83	0.5	0.3	n.d.	3.2	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	82	-----	n.d.	n.d.	0.60	10(4)	0	0%
Phosphorus, Total (mg/l)	0.01	82	-----	0.03	n.d.	0.66	-----	-----	-----
Suspended Solids, Total (mg/l)	4	83	-----	n.d.	n.d.	34	158(2), 90(3)	0	0%
Turbidity (NTU)	0.1	84	11.7	6.8	0.1	67.0	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	-----	n.d.	n.d.	n.d.	750(2), 87(3)		
Antimony, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	n.d.	6(4)	0	0%
Arsenic, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	3	340(2), 150(3), 50(4)	0	0%
Barium, Dissolved (ug/l)	5	4	-----	n.d.	n.d.	n.d.	1,000(4)		
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	4(4)	0	0%
Cadmium, Dissolved (ug/l)	0.2	18	-----	n.d.	n.d.	n.d.	11.8(2), 4.8(3), 5(4)	0	0%
Chromium, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	n.d.	3,630(2), 174(3), 100(4)	0	0%
Copper, Dissolved (ug/l)	2	18	-----	n.d.	n.d.	5	31.3(2), 19.4(3), 1,000(4)	0	0%
Lead, Dissolved (ug/l)	0.5	18	-----	n.d.	n.d.	n.d.	242(2), 9.4(3), 15(4)	0	0%
Mercury, Dissolved (ug/l)	0.02	18	-----	n.d.	n.d.	n.d.	-----	0	0%
Mercury, Total (ug/l)	0.02	18	-----	n.d.	n.d.	n.d.	1.7(2), 0.91(3), 0.05(4)	0	0%
Nickel, Dissolved (ug/l)	10	17	-----	n.d.	n.d.	n.d.	966(2), 107(3), 100(4)	0	0%
Selenium, Total (ug/l)	1	18	-----	n.d.	n.d.	4	20(2), 5(3), 50(4)	0	0%
Silver, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	14.7	0	0%
Zinc, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	26	247(2,3), 9,100(4)	0	0%
Alachlor, Total (ug/l)***	0.05	70	-----	n.d.	n.d.	n.d.	-----	-----	-----
Atrazine, Total (ug/l)***	0.05	70	-----	n.d.	n.d.	1.26	-----	-----	-----
Metolachlor, Total (ug/l)***	0.05	70	-----	n.d.	n.d.	0.30	-----	-----	-----
Pesticide Scan (ug/l)****	0.05						*****	-----	-----
Profluralin		5	-----	n.d.	n.d.	0.16			

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 258. Summary of water quality conditions monitored in the Missouri River near Verdel, Nebraska (i.e., site MORRR0851) at RM851 during the 5-year period of 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	80	24,663	27,219	3,981	41,299	-----	-----	-----
Water Temperature (C)	0.1	83	14.9	16.2	0.6	28.6	27.0 29.0	1 0	1% 0%
Dissolved Oxygen (mg/l)	0.1	81	9.6	9.1	6.4	13.8	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	83	96.3	97.5	73.3	118.8	-----	-----	-----
Specific Conductance (umho/cm)	1	83	691	704	432	800	2,000[5]	0	0%
pH (S.U.)	0.1	83	8.3	8.3	7.1	9.1	≥6.5 & ≤9.0	1	1%
Oxidation-Reduction Potential	1	31	394	393	315	482	-----	-----	-----
Alkalinity, Total (mg/l)	7	82	171	171	118	220	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	81	-----	0.07	n.d.	0.59	4.71 [1,2], 1.37 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	80	3.3	3.0	1.6	12.8	-----	-----	-----
Chloride (mg/l)	1	81	11	10	5	31	860[2], 230[3], 250[4]	0	0%
Chemical Oxygen Demand (mg/l)	2	82	8	8	n.d.	47	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	33	484	480	310	780	500[6]	9[6]	27%[6]
Hardness, Total (mg/l)	0.4	14	227	235	167	242	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	83	0.5	0.4	n.d.	3.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	82	-----	n.d.	n.d.	0.50	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	81	0.05	0.02	n.d.	0.75	-----	-----	-----
Suspended Solids, Total (mg/l)	4	82	----	5	n.d.	230	158[2], 90[3]	1, 1	1%, 1%
Turbidity (NTU)	0.1	80	14.6	8.4	0.3	128.7	-----	-----	-----
Aluminum, Dissolved (mg/l)	5	4	-----	5	n.d.	5	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	0.8	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	4	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	37	37	33	41	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	18	-----	n.d.	n.d.	n.d.	13.5[2], 0.45[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	n.d.	1,192[2], 155[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	18	-----	n.d.	n.d.	n.d.	30.1[2], 18.6[3], 1,000[4]	0	0%
Lead, Dissolved (ug/l)	0.5	18	-----	n.d.	n.d.	n.d.	161[2], 6.3[3], 15[4]	0	0%
Mercury, Dissolved (ug/l)	0.02	18	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	18	-----	n.d.	n.d.	n.d.	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	n.d.	965[2], 107[3], 100[4]	0	0%
Selenium, Total (ug/l)	1	18	-----	n.d.	n.d.	2	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	15.0[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	18	-----	n.d.	n.d.	8	242[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	n.d.	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	0.27	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	0.20	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	12					*****	-----	-----
Profluralin		5	-----	n.d.	n.d.	0.20		-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 259. **S**ummary of monthly (May through September) water quality conditions monitored in Gavins Point Reservoir near Gavins Point Dam (Site GPTLK0811A) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results*						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean**	Median	Min.	Max.	State WQS Criteria***	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation (ft-msl)	0.1	24	1206.6	1206.6	1205.5	1207.9	-----	-----	-----
Water Temperature (C)	0.1	293	21.1	22.4	10.6	27.8	27.0 29.0	2 0	1% 0%
Dissolved Oxygen (mg/l)	0.1	293	7.6	7.9	1.4	11.6	≥ 5.0	24	8%
Dissolved Oxygen (% Sat.)	0.1	293	88.7	93.4	16.7	112.5	-----	-----	-----
Specific Conductance (umho/cm)	1	293	679	689	555	761	2,000[(5)]	-----	-----
pH (S.U.)	0.1	282	8.4	8.4	6.9	9.4	≥6.5 & ≤9.0	6	2%
Turbidity (NTUs)	0.1	258	20.3	15.9	2.3	131.7	-----	-----	-----
Oxidation-Reduction Potential (mV)	1	282	358	362	266	452	-----	-----	-----
Secchi Depth (in.)	1	25	34	34	18	66	-----	-----	-----
Alkalinity, Total (mg/l)	7	48	178	168	130	740	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	48	-----	0.06	n.d.	0.46	2.59 [(1,2)], 0.74 [(1,3)]	0	0%
Carbon, Total Organic (mg/l)	0.05	46	3.2	3.2	2.0	4.0	-----	-----	-----
Chemical Oxygen Demand (mg/l)	2	22	11	11	n.d.	19	-----	-----	-----
Chloride (mg/l)	1	22	10	10	8	14	860[(2)], 230[(3)], 250[(4)]	0	0%
Chlorophyll *a* (ug/l) – Field Probe	1	245	9	8	n.d.	29	8[(6)]	125	51%
Chlorophyll *a* (ug/l) – Lab Determined	1	23	6	5	n.d.	15	8[(6)]	8	35%
Dissolved Solids, Total (mg/l)	5	24	472	463	400	532	1,750[(4)], 500[(7)]	0, 4	0%, 17%
Iron, Dissolved (ug/l)	40	15	-----	n.d.	n.d.	156	1,000[(3)]	0	0%
Iron, Total (ug/l)	40	15	392	360	190	727	300[(7)]	10	67%
Nitrogen, Total Kjeldahl (mg/l)	0.1	48	0.4	0.4	n.d.	1.5	-----	-----	-----
Nitrogen, Total (mg/l)	0.1	48	0.4	0.4	n.d.	1.5	0 57[(6)]	12	25%
Manganese, Dissolved (ug/l)	1	15	48	7	n.d.	225	1,000[(3)]	0	0%
Manganese, Total (ug/l)	1	15	106	60	29	329	50[(7)]	9	60%
Nitrate-Nitrite N, Total (mg/l)	0.02	48	-----	n.d.	n.d.	0.13	10[(4)]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	18	-----	n.d	n.d.	0.07	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	48	0.05	0.04	n.d.	0.23	0.06[(6)]	10	21%
Phosphorus-Ortho, Dissolved (mg/l)	0.01	48	-----	n.d.	n.d.	0.03	-----	-----	-----
Sulfate (mg/l)	1	24	207	210	177	223	875[(4)], 250[(7)]	0	0%
Suspended Solids, Total (mg/l)	4	48	9	8	n.d.	32	158[(2)], 90[(3)]	0	0%
Microcystins, Total (ug/l)	0.2	14	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Results are a combination of all sampling depths.

** Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

*** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Daily maximum criterion for domestic water supply.
(5) Agricultural criterion for surface waters.
(6) Nutrient criteria. (Gavins Point Reservoir is classified R9 by Nebraska for application of nutrient criteria.)
(7) The criteria for total dissolved solids, iron, and manganese are listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

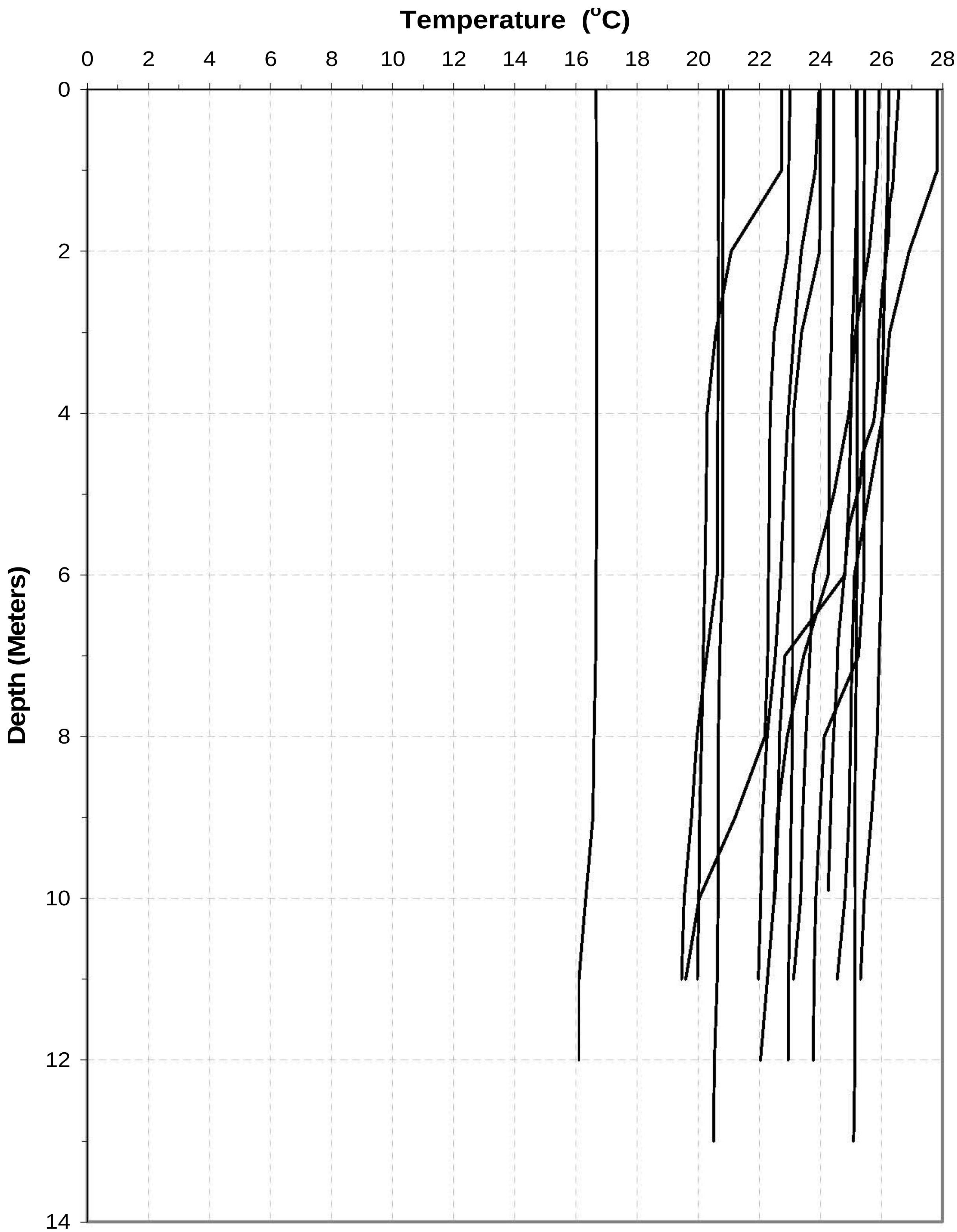


Plate 260. Temperature depth profiles for Gavins Point Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) during the summer months over the 5-year period 2003 to 2007.

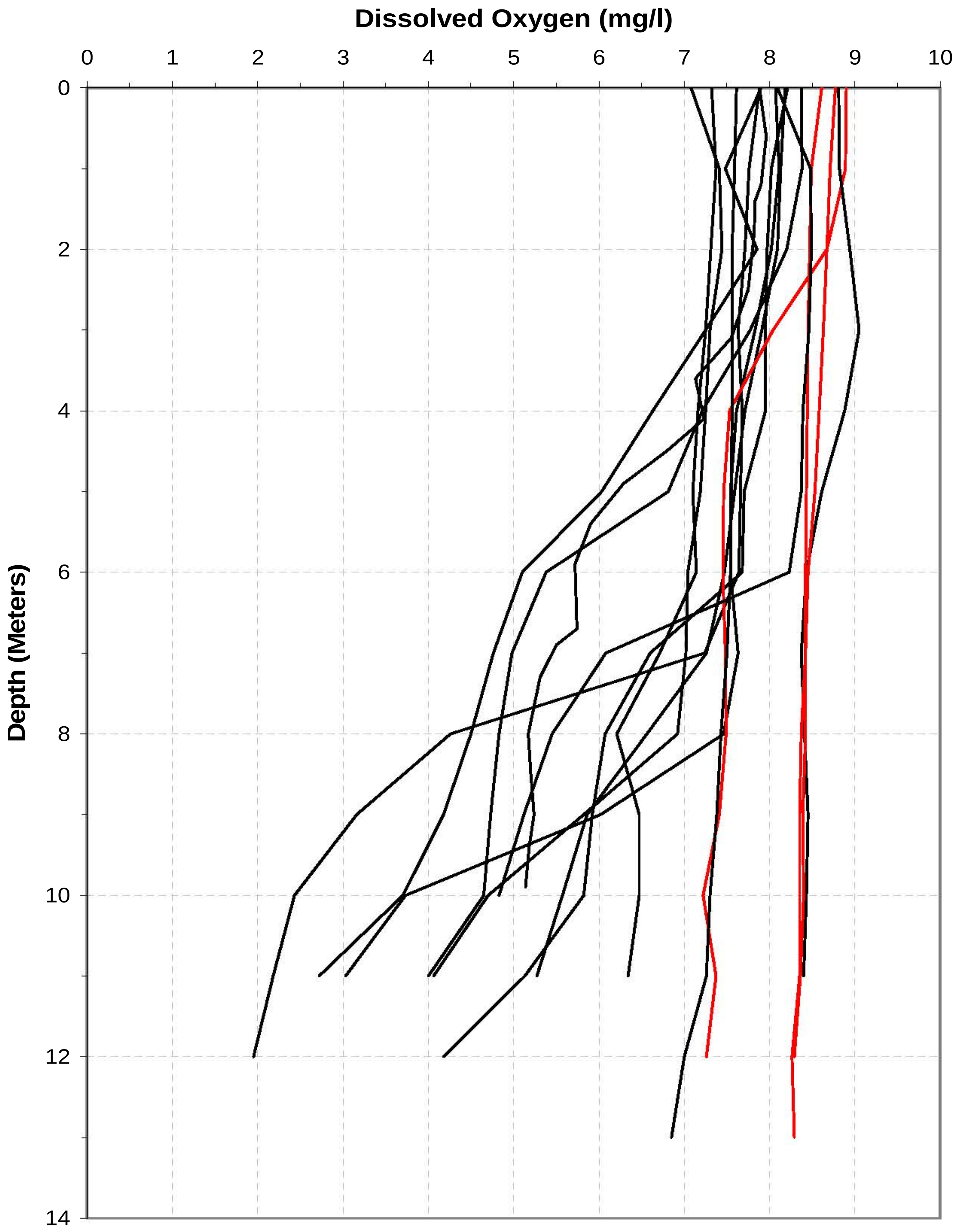


Plate 261. Dissolved oxygen depth profiles for Gavins Point Reservoir generated from data collected at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) during the summer months over the 5-year period 2003 to 2007. (Note: Red profile plots were measured in the month of September.)

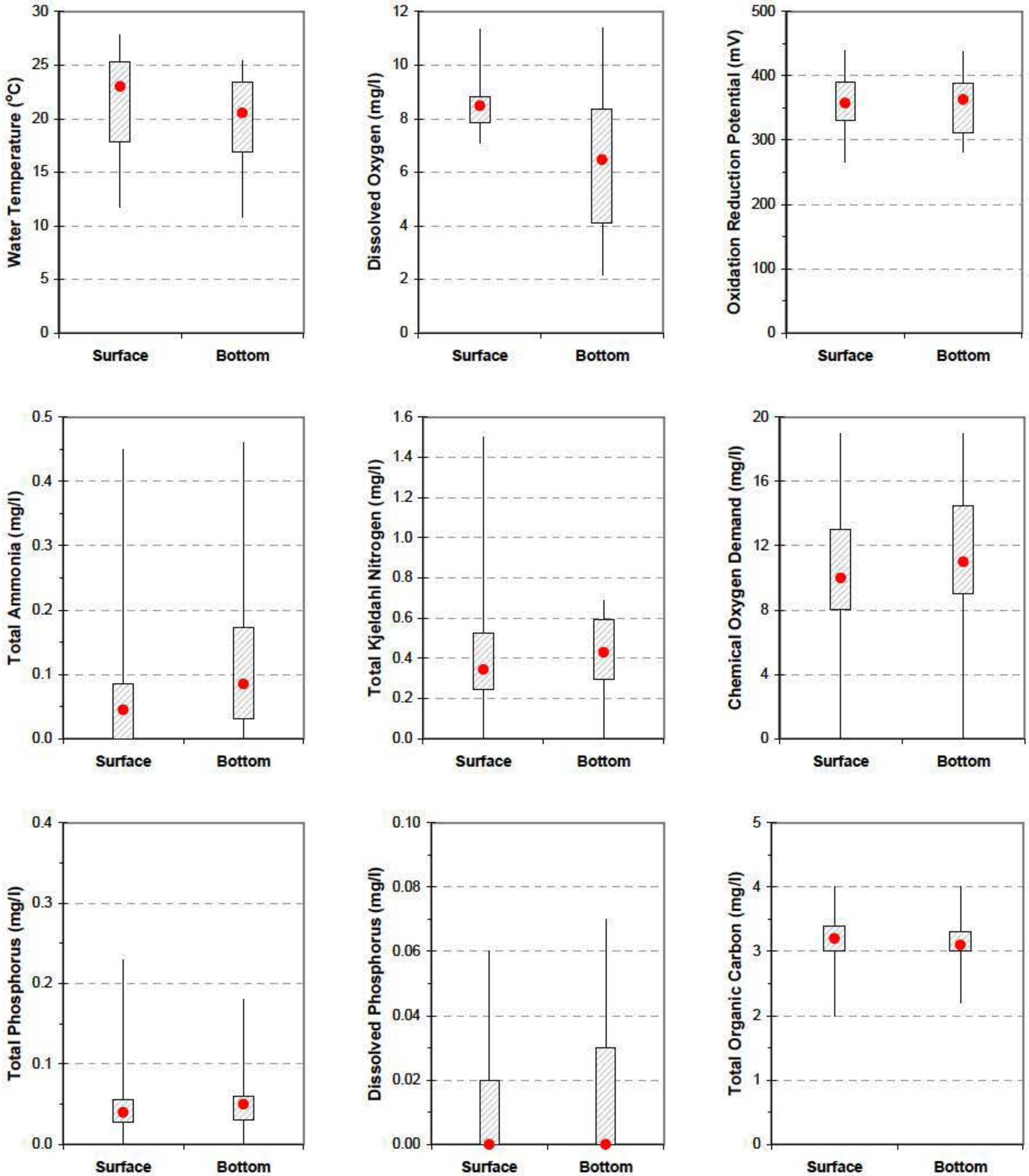


Plate 262. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, chemical oxygen demand, total phosphorus, dissolved phosphorus, and total organic carbon measured in Gavins Point Reservoir at site GPTLK0811A during the summer months of 2003 through 2007. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

Plate 263. Total biovolume, number of genera present and percent composition (based on biovolume) by taxonomic division for phytoplankton grab samples collected at the near-dam, deepwater ambient monitoring site (i.e., site GPTLK0811A) at Gavins Point Reservoir during the 4-year period 2004 through 2007.

Date	Total Sample Biovolume (um^3)	Bacillariophyta		Chlorophyta		Chrysophyta		Cryptophyta		Cyanobacteria		Pyrrophyta		Euglenophyta		Shannon-Weaver Genera Diversity
		No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	No. of Genera	Percent Comp.	
Jun 2004	2,020,993	1	0 38	0	-----	0	-----	2	0.37	2	0.25	0	-----	0	-----	1.49
Jul 2004	1,260,399	0	-----	0	-----	0	-----	1	0.27	2	0.73	0	-----	0	-----	0.68
Aug 2004	428,086,948	7	0 33	3	<0.01	1	0.01	2	0.06	2	<0.01	1	0.61	1	<0.01	1.24
May 2005	170,642,733	6	0.86	3	0.08	0	-----	1	0.05	1	<0.01	0	-----	0	-----	1.29
Jun 2005	75,346,609	3	0.78	3	0.03	0	-----	1	0.15	3	<0.01	1	0.03	0	-----	1.35
Jul 2005	621,134,038	10	0.93	3	0.06	1	<0.01	1	<0.01	3	<0.01	0	-----	0	-----	1.61
Aug 2005	400,199,396	7	0.55	6	0.02	2	0.05	1	0.26	4	0.04	3	0.06	2	0.04	2.28
Sep 2005	337,716,027	11	0.49	10	0.04	0	-----	2	0.37	6	0.03	2	0.06	2	0.01	2.21
May 2006	1,170,506,627	12	0.97	13	0.01	0	-----	1	<0.01	2	<0.01	0	-----	2	0.01	1.19
Jun 2006	280,054,880	10	0.78	17	0.16	2	0.01	1	0.01	0	-----	1	0.03	1	0.01	2.15
Jul 2006	710,790,547	15	0.89	9	0.06	1	<0.01	1	<0.01	1	<0.01	3	0.04	1	0.01	2.01
Aug 2006	528,360,481	13	0.75	11	0.10	1	<0.01	1	<0.01	8	0.11	1	0.01	2	0.02	2.52
Sep 2006	520,570,174	19	0.72	22	0.22	0	-----	1	0.01	4	0.03	0	-----	2	0.02	2.84
May 2007	3,539,604,890	10	0.90	10	0.09	0	-----	1	<0.01	0	-----	0	-----	0	-----	1.32
Jun 2007	1,242,668,868	11	0.83	4	0.11	2	0.03	2	0.02	1	<0.01	1	<0.01	0	-----	1.83
Jul 2007	876,807,100	8	0.92	9	0.05	1	<0.01	1	0.03	0	-----	1	<0.01	0	-----	1.44
Aug 2007	674,471,295	8	0.69	11	0.06	0	-----	2	0.02	4	0.03	2	0.18	1	0.01	2.12
Sep 2007	2,492,800,160	12	0.88	13	0.02	0	-----	1	0.01	5	0.10	1	<0.01	2	<0.01	1.67
Mean	**781,835,676**	**9.1**	**0.74**	**8.2**	**0.07**	**0.6**	**0.01**	**1.3**	**0.09**	**2.7**	**0.09**	**0.9**	**0.09**	**0.9**	**0.01**	**1.74**

* Mean percent composition represents the mean when taxa of that division are present.

Plate 264. Dominant taxa present in phytoplankton grab samples collected at the near-dam monitoring site (site GPTLK0811A) at Gavins Point Reservoir during the period 2004 through 2007.

Date	Division	Dominant Taxa*	Percent of Total Biovolume
Jun 2004	Bacillariophyta	*Fragilaria spp.*	0.38
	Cryptophyta	*Cryptomonas spp.*	0.20
	Cryptophyta	*Rhodomonas minuta*	0.17
	Cyanobacteria	*Aphanothece spp.*	0.17
Jul 2004	Cyanobacteria	*Aphanocapsa spp.*	0.71
	Cryptophyta	*Rhodomonas minuta*	0.28
August 2004	Pyrrophyta	*Ceratium hirundinella*	0.61
	Bacillariophyta	*Fragilaria crotonensis*	0.23
May 2005	Bacillariophyta	*Fragilaria crotonensis*	0.62
	Bacillariophyta	*Asterionella formossa*	0.19
June 2005	Bacillariophyta	*Aulacoseira granulata*	0.54
	Bacillariophyta	*Stephanodiscus spp.*	0.21
	Cryptophyta	*Rhodomonas minuta*	0.15
July 2006	Bacillariophyta	*Cyclotella spp.*	0.47
	Bacillariophyta	*Fragilaria crotonensis*	0.22
	Bacillariophyta	*Aulacoseira spp.*	0.15
August 2006	Bacillariophyta	*Fragilaria crotonensis*	0.29
	Cryptophyta	*Cryptomonas spp.*	0.19
September 2006	Cryptophyta	*Rhodomonas minuta*	0.35
	Bacillariophyta	*Aulacoseira granulata*	0.19
	Bacillariophyta	*Fragilaria crotonensis*	0.10
May 2006	Bacillariophyta	*Fragilaria crotonensis*	0.42
	Bacillariophyta	*Asterionella formossa*	0.38
June 2006	Bacillariophyta	*Fragilaria crotonensis*	0.42
July 2006	Bacillariophyta	*Aulacoseira spp.*	0.41
	Bacillariophyta	*Fragilaria crotonensis*	0.19
August 2006	Bacillariophyta	*Fragilaria crotonensis*	0.19
	Bacillariophyta	*Aulacoseira granulata*	0.14
September 2006	Bacillariophyta	*Stephanodiscus niagarea*	0.24
	Bacillariophyta	*Aulacoseira granulata*	0.11
May 2007	Bacillariophyta	*Fragilaria capucina*	0.64
June 2007	Bacillariophyta	*Aulacoseira spp.*	0.30
	Bacillariophyta	*Fragilaria capucina*	0.26
	Bacillariophyta	*Stephanodiscus niagarae.*	0.12
July 2007	Bacillariophyta	*Cyclotella spp.*	0.41
	Bacillariophyta	*Stephanodiscus niagarae.*	0.30
	Bacillariophyta	*Aulacoseira spp.*	0.17
August 2007	Bacillariophyta	*Stephanodiscus niagarae.*	0.23
	Bacillariophyta	*Aulacoseira spp.*	0.19
	Pyrrophyta	*Peridinium spp.*	0.13
September 2007	Bacillariophyta	*Stephanodiscus niagarae.*	0.41
	Bacillariophyta	*Fragilaria capucina*	0.26
	Cyanobacteria	*Anabaenopsis circularis*	0.10

* Dominant taxa are genera or species (depending on identification level) that comprised more than 10% of the total sample biovolume.

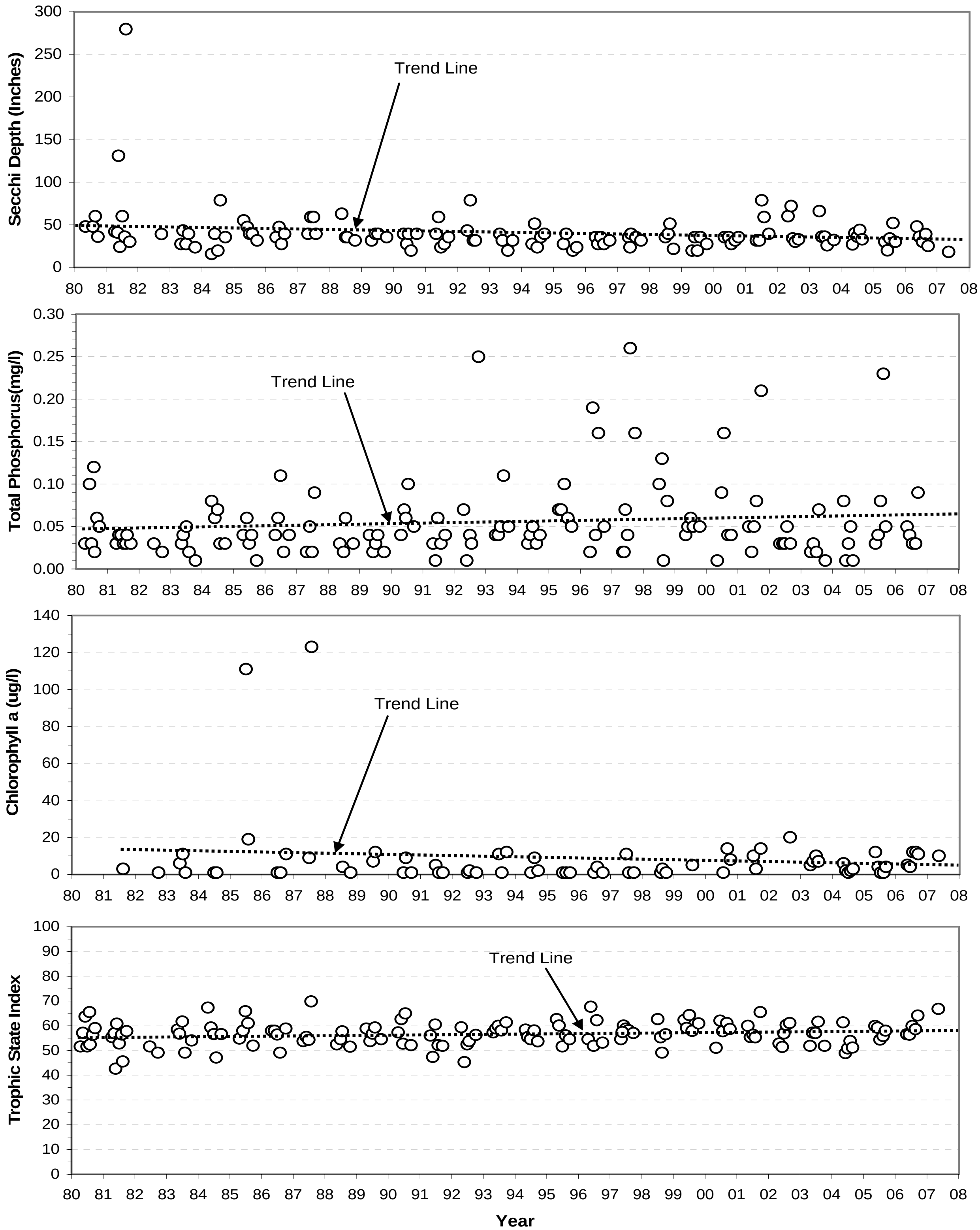


Plate 265. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Gavins Point Reservoir at the near-dam, ambient site (i.e., site GTPLK0811A) over the 28-year period of 1980 to 2007.

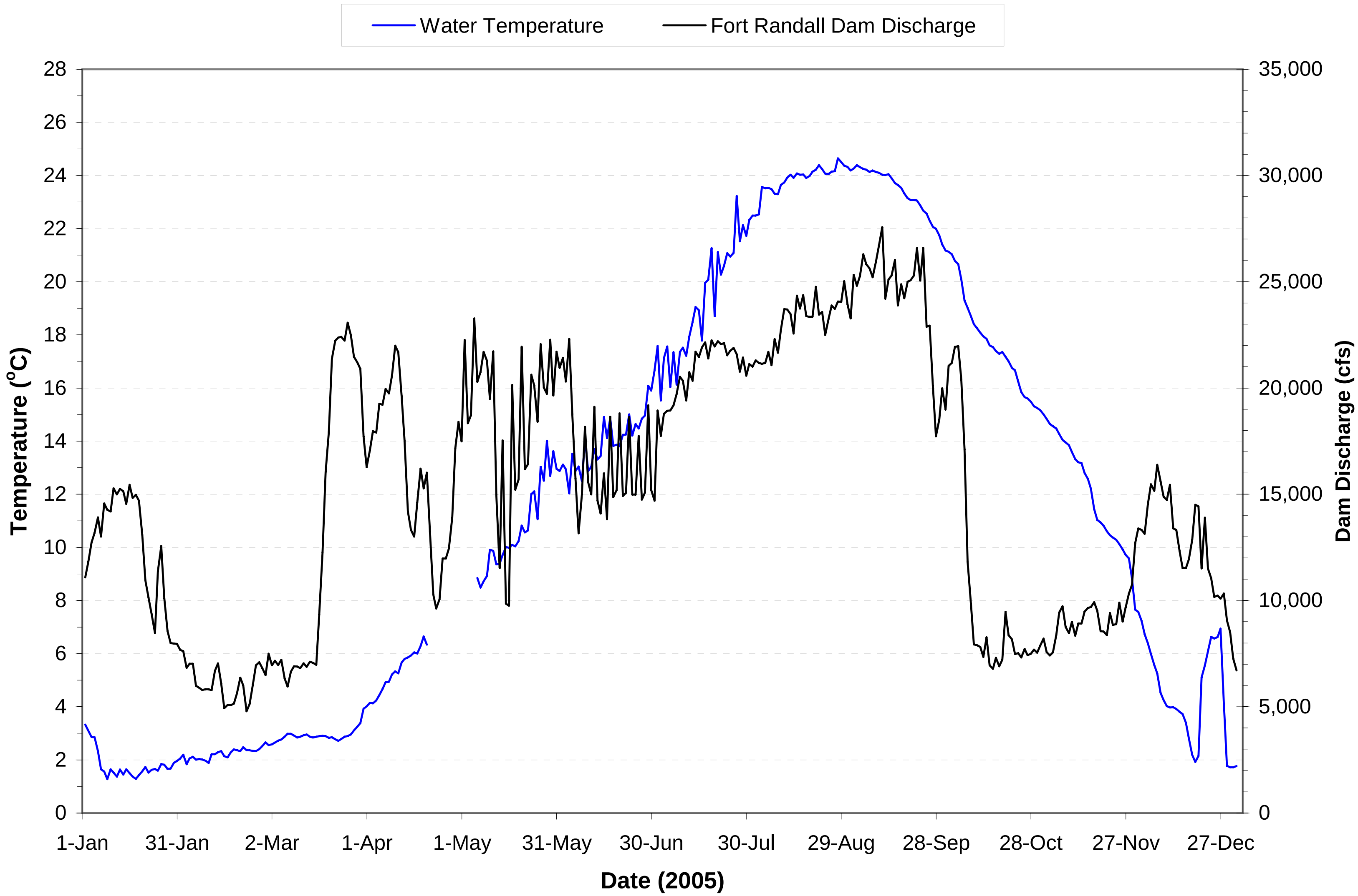


Plate 266. Mean daily water temperature and discharge of the Missouri River at Fort Randall Dam (i.e., site FTRPP1) for 2005. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Fort Randall Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

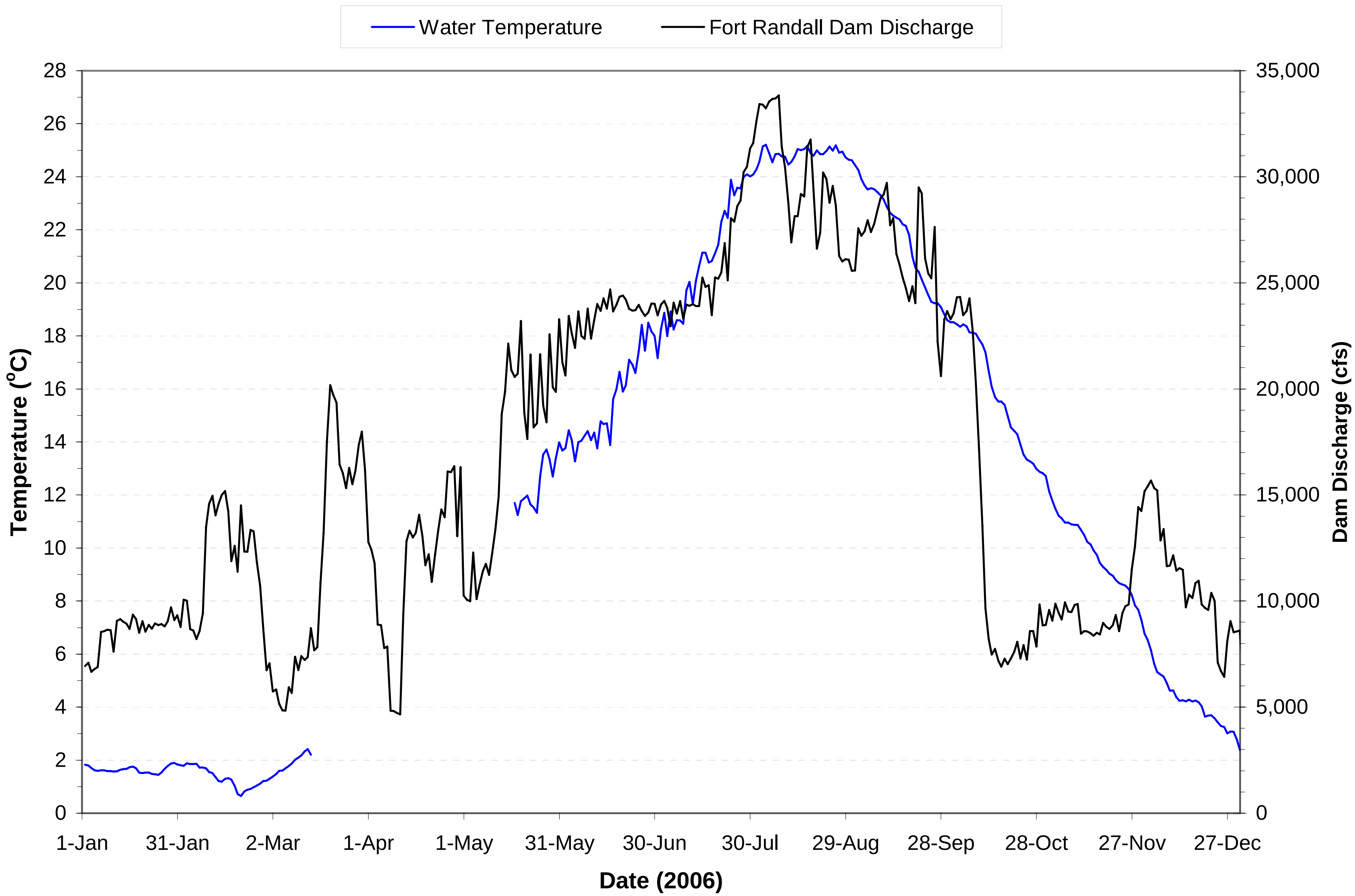


Plate 267. Mean daily water temperature and discharge of the Missouri River at Fort Randall Dam (i.e., site FTRPP1) for 2006. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Fort Randall Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.**)**

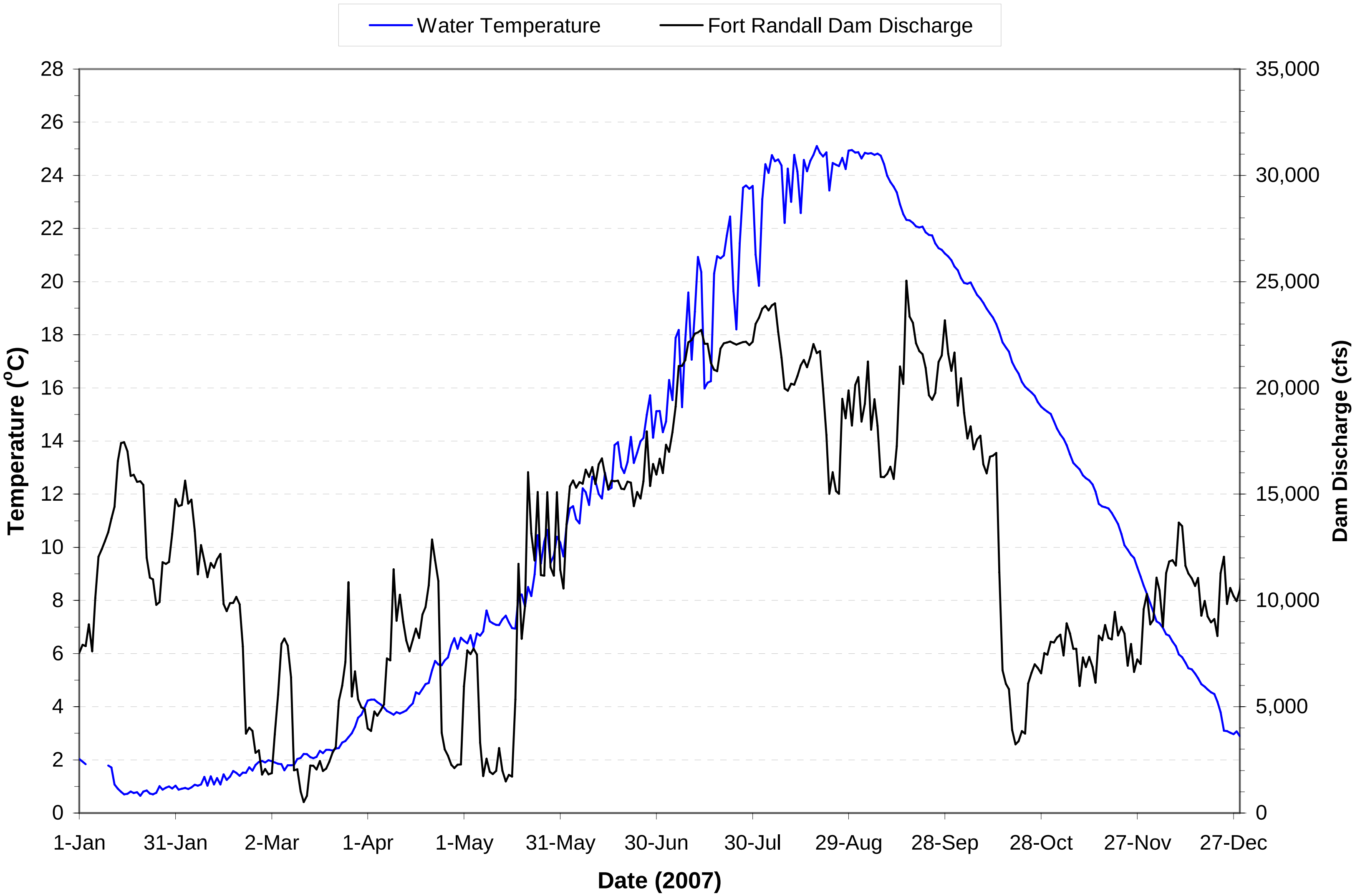


Plate 268. Mean daily water temperature and discharge of the Missouri River at Fort Randall Dam (i.e., site FTRPP1) for 2007. Mean daily temperatures and discharges based on hourly measurements recorded on discharge through Fort Randall Dam. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

Plate 269. Summary of water quality conditions monitored in the Niobrara River near Verdel, Nebraska by the Nebraska Department of Environmental Quality during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	0.1	78	1,737	1,495	674	11,600	-----	-----	-----
Water Temperature (C)	0.1	81	16.3	18.8	-0.3	34.7	29.0	8	10%
Dissolved Oxygen (mg/l)	0.1	80	10.3	9.1	7.3	19.6	≥ 5.0	0	0%
Specific Conductance (umho/cm)	1	81	256	256	102	366	-----	-----	-----
pH (S.U.)	0.1	81	8.3	8.2	7.6	9.0	≥6.5 & ≤9.0	0	0%
Turbidity (NTUs)	0.1	79	129	101	12	536	-----	-----	-----
Alkalinity, Total (mg/l)	7	4	111	113	104	115	-----	-----	-----
Ammonia, Total (mg/l)	0.05	78	-----	n.d.	n.d.	0.37	5.72 (1,2), 1.36(1,3)	0	0%
Hardness, Total (mg/l)	1	18	113	109	91	161	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.5	78	-----	0.90	n.d.	5.7	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.05	78	-----	0.80	n.d.	7.84	10(4)	0	0%
Phosphorus, Total (mg/l)	0.05	78	0.28	0.24	0.05	2.18	-----	-----	-----
Suspended Solids, Total (mg/l)	5	78	173	123	n.d.	2,050	-----	-----	-----
Arsenic, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	340(2), 16.7(3)	0	0%
Cadmium, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	6.4(2), 0.3(3)	***	***
Chromium, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	n.d.	635(2), 83(3)	0	0%
Copper, Dissolved (ug/l)	2	18	-----	n.d.	n.d.	n.d.	14.6(2), 9.6(3)	0	0%
Lead, Dissolved (ug/l)	5	18	-----	n.d.	n.d.	n.d.	71(2), 2.8(3)	***	***
Mercury, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	0.77(3)	***	***
Nickel, Dissolved (ug/l)	10	17	-----	n.d.	n.d.	n.d.	504(2), 56(3)	0	0%
Selenium, Total (ug/l)	1	17	-----	n.d.	n.d.	n.d.	20(2), 5(3)	0	0%
Silver, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	4.0(2)	0	0%
Zinc, Dissolved (ug/l)	10	16	-----	n.d.	n.d.	n.d.	126(2,3)	0	0%
Alachlor, Total (ug/l)	0.05	64	-----	n.d.	n.d.	0.20	760(2), 76(3)	0	0%
Atrazine, Total (ug/l)	0.05	74	-----	n.d.	n.d.	0.50	330(2), 12(3)	0	0%
Metolachlor, Total (ug/l)	0.05	75	-----	n.d.	n.d.	0.50	390(2), 100(3)	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e., log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
(4) Public Drinking Water Supply.
Note: Many of Nebraska's WQS criteria for metals are hardness based. As appropriate, listed criteria were calculated using the median hardness.

*** WQS criteria below method detection limit.

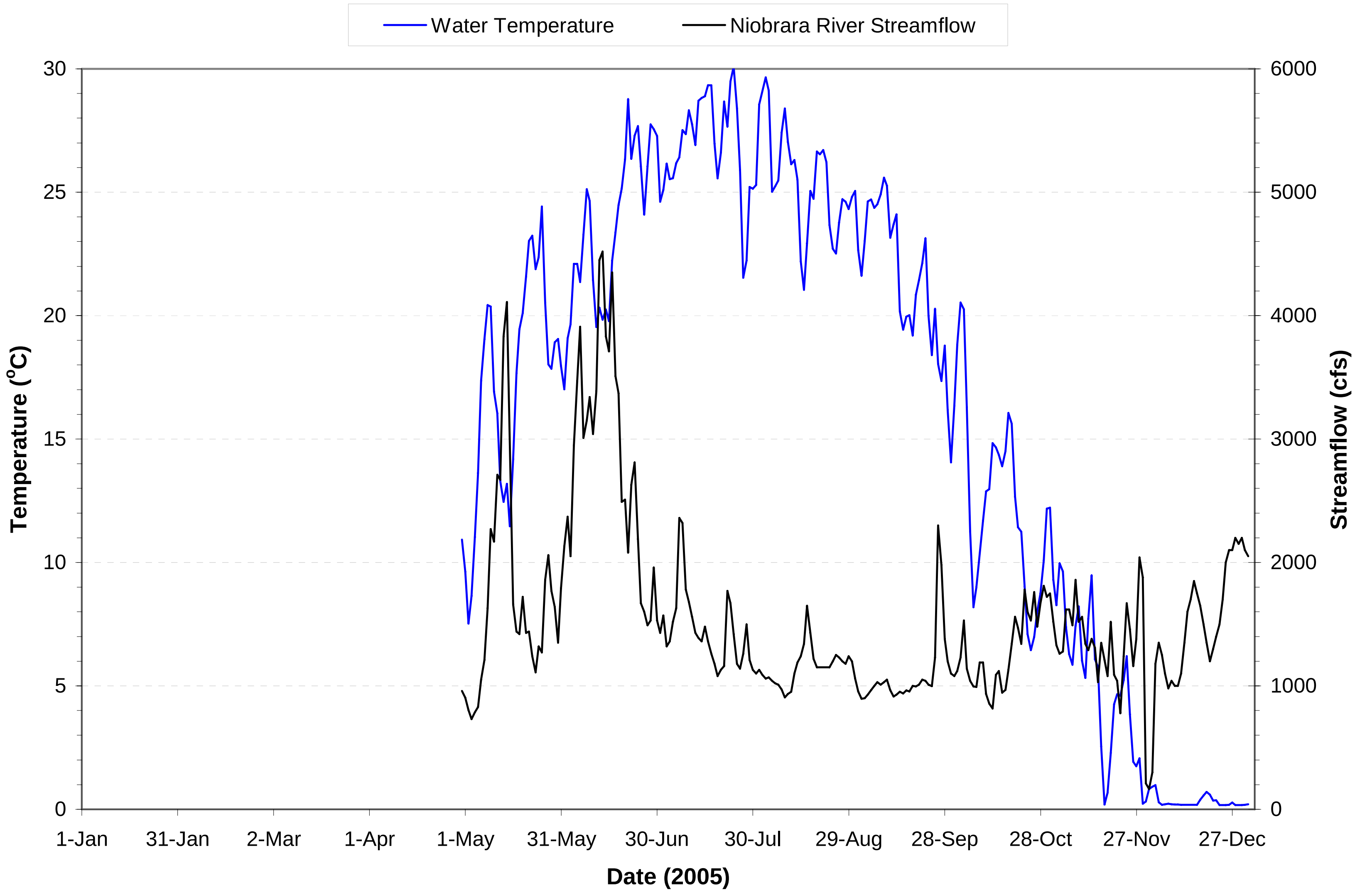


Plate 270. Mean daily water temperature and streamflow of the Niobrara River near Verdel, Nebraska (i.e., site USGS 06465500) for 2005. Mean daily temperatures and streamflows based on hourly measurements recorded at the USGS gaging station.

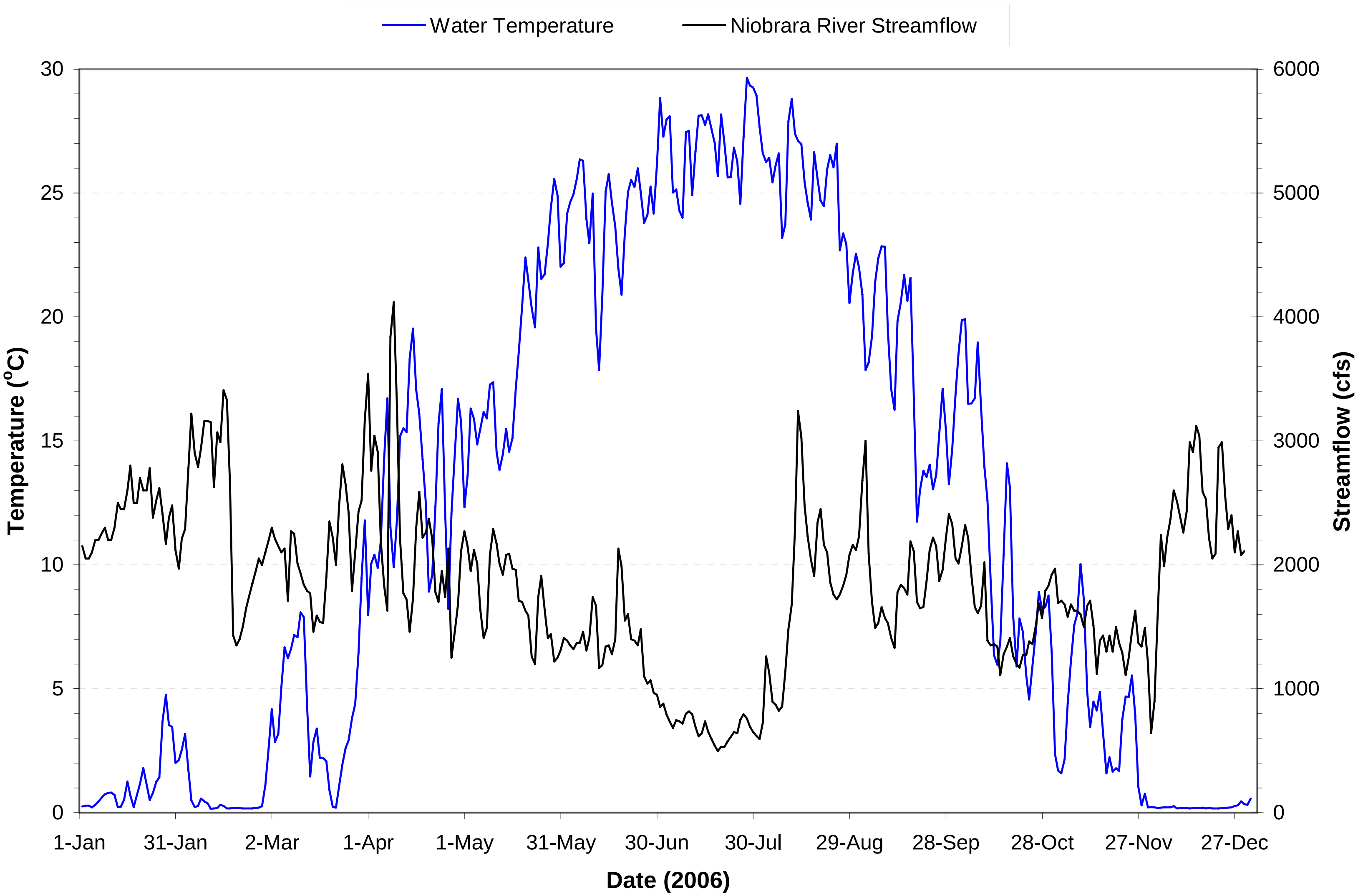


Plate 271. Mean daily water temperature and streamflow of the Niobrara River near Verdel, Nebraska (i.e., site USGS 06465500) for 2006. Mean daily temperatures and streamflows based on hourly measurements recorded at the USGS gaging station.

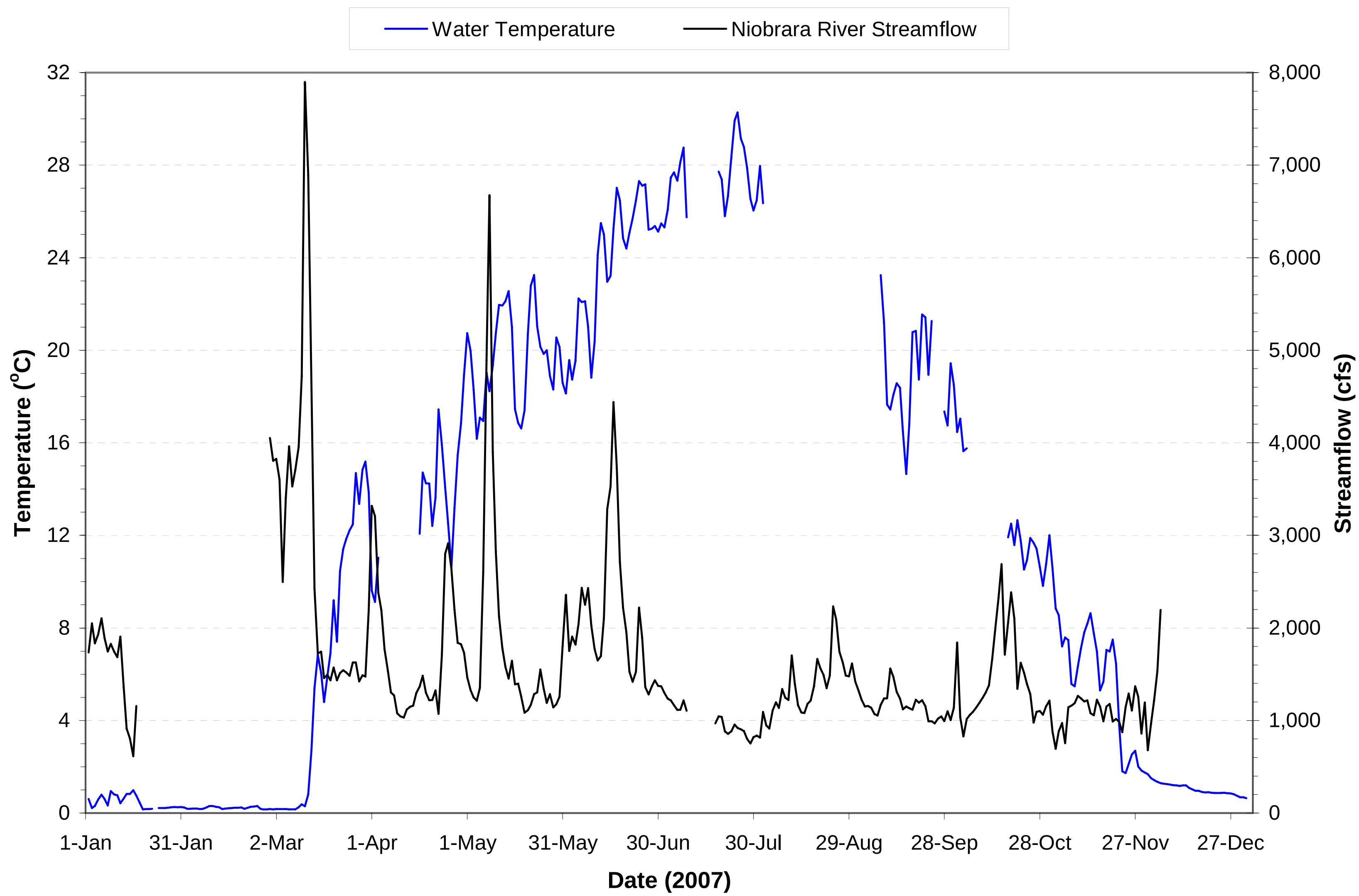


Plate 272. Mean daily water temperature and streamflow of the Niobrara River near Verdel, Nebraska (i.e., site USGS 06465500) for 2007. Mean daily temperatures and streamflows based on hourly measurements recorded at the USGS gaging station.

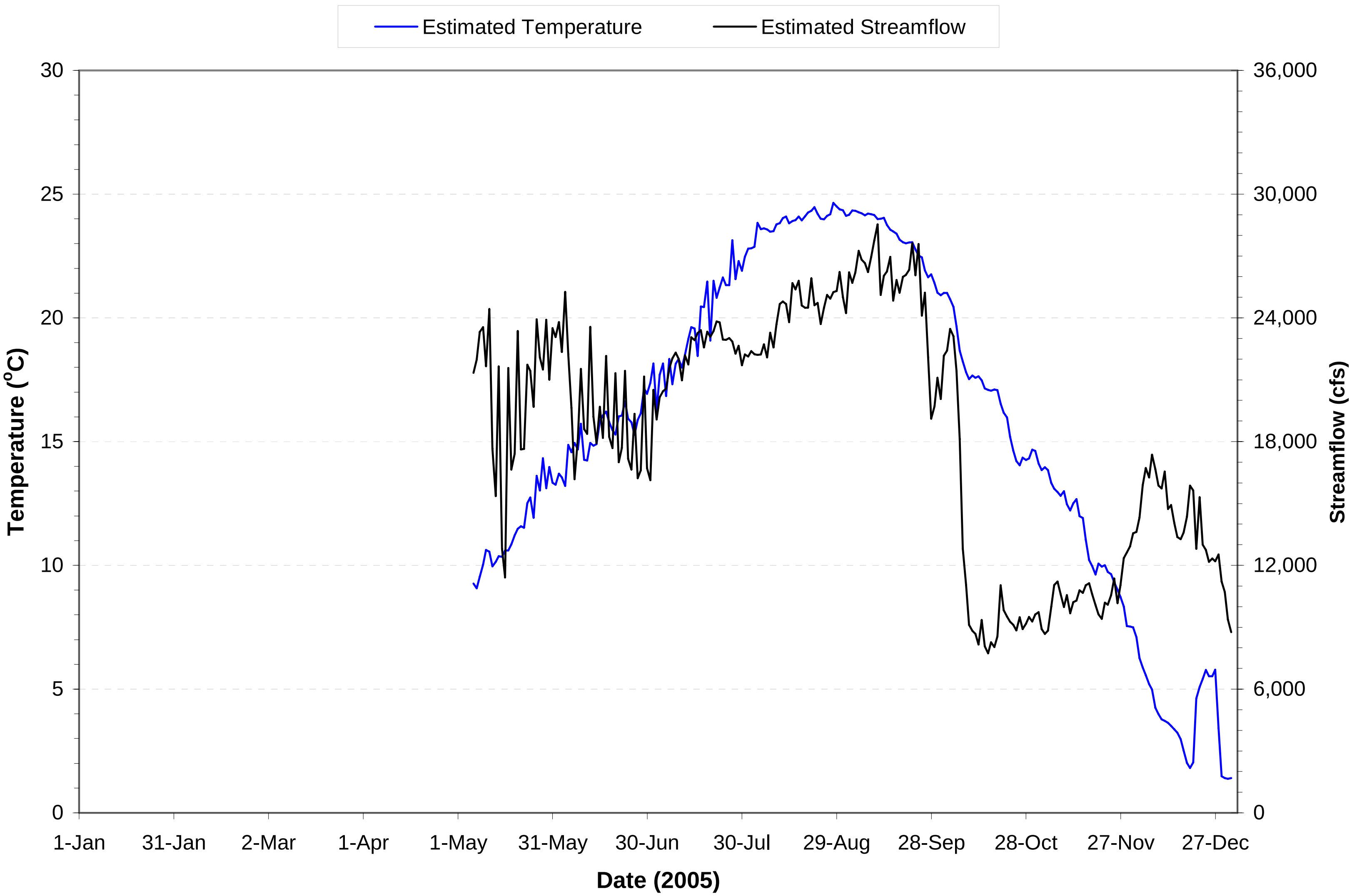


Plate 273. Mean daily water temperature and streamflow estimated for the Missouri River inflow to Gavins Point Reservoir for 2005. The mean daily discharge was estimated by adding the mean daily discharges determined for the Fort Randall Dam outflow and Niobrara River near Verdel, Nebraska at USGS gaging station 06465500. The mean daily temperature was estimated by flow weighting the mean daily water temperatures determined at the two sites.

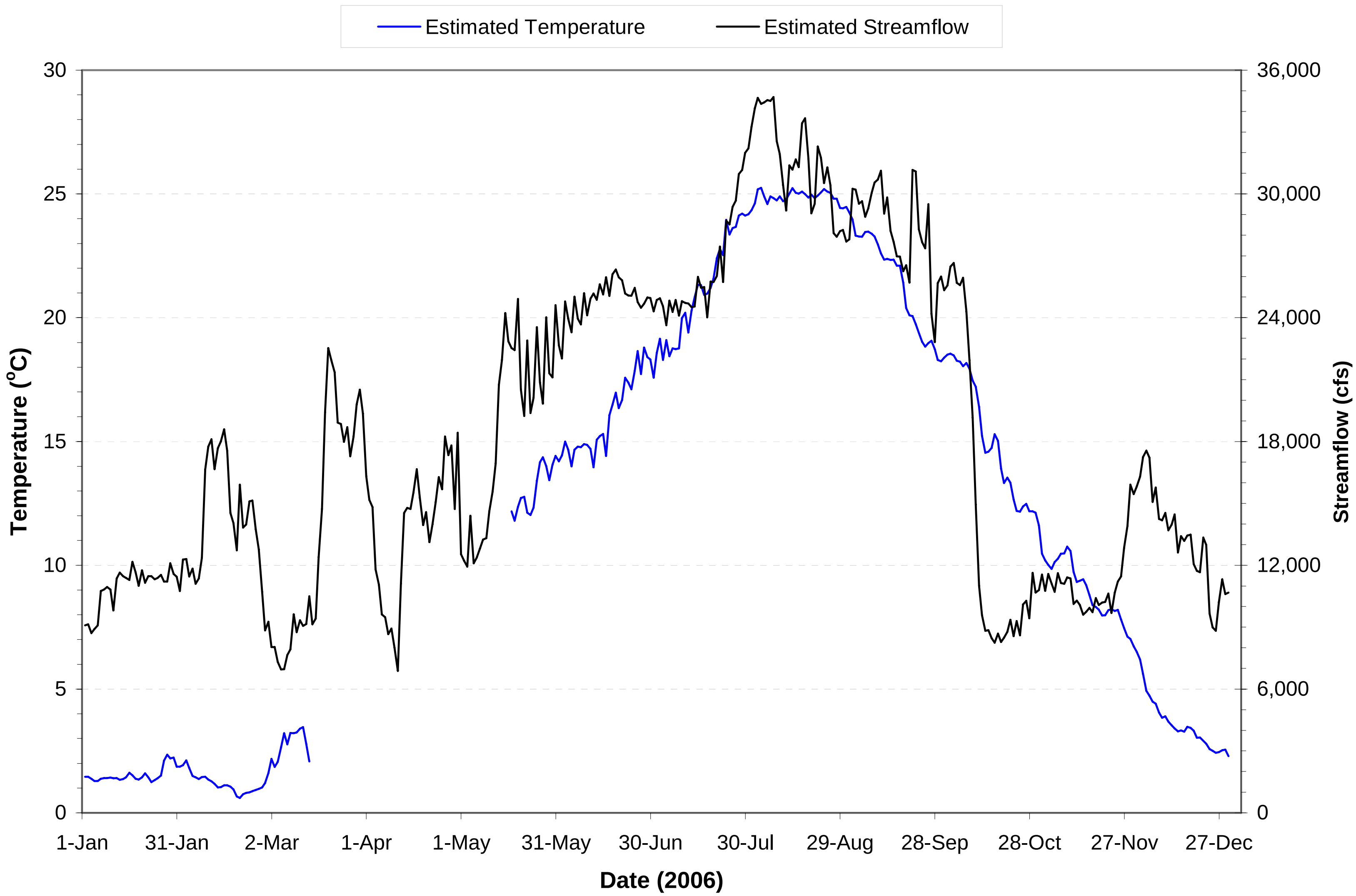


Plate 274. Mean daily water temperature and streamflow estimated for the Missouri River inflow to Gavins Point Reservoir for 2006. The mean daily discharge was estimated by adding the mean daily discharges determined for the Fort Randall Dam outflow and Niobrara River near Verdel, Nebraska at USGS gaging station 06465500. The mean daily temperature was estimated by flow weighting the mean daily water temperatures determined at the two sites. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.**)**

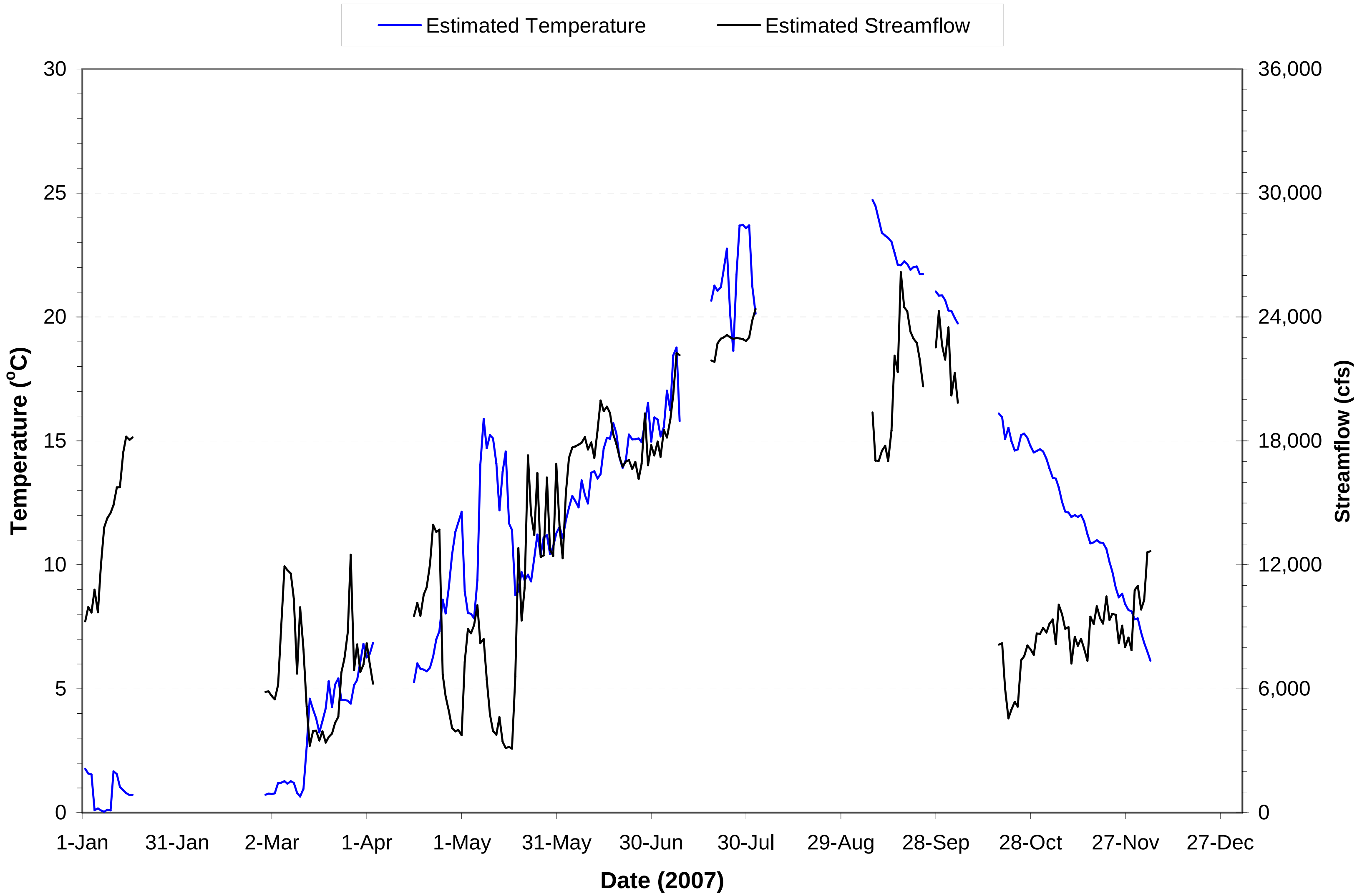


Plate 275. Mean daily water temperature and streamflow estimated for the Missouri River inflow to Gavins Point Reservoir for 2007. The mean daily discharge was estimated by adding the mean daily discharges determined for the Fort Randall Dam outflow and Niobrara River near Verdel, Nebraska at USGS gaging station 06465500. The mean daily temperature was estimated by flow weighting the mean daily water temperatures determined at the two sites. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.**)**

Plate 276. Summary of water quality conditions monitored on water discharged through Gavins Point Dam (i.e., site GTPPP1) during the 4-year period of 2004 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Dam Discharge (cfs)	1	38	17,895	18,000	8,000	30,00	-----	-----	-----
Water Temperature (C)	0.1	35	14.2	14.4	0.9	26.3	27.0 29.0	0 0	0% 0%
Dissolved Oxygen (mg/l)	0.1	34	9.6	9.1	6.2	13.5	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	34	93.9	95.8	76	110.3	-----	-----	-----
Specific Conductance (umho/cm)	1	35	644	650	463	738	2,000[5]	-----	-----
pH (S.U.)	0.1	34	8.3	8.3	7.8	9.4	≥6.5 & ≤9.0	1	3%
Oxidation-Reduction Potential	1	17	382	379	252	503	-----	-----	-----
Alkalinity, Total (mg/l)	7	38	162	160	140	197	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	38	-----	0.04	n.d.	0.37	4.71[1,2], 1.52[1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	37	3.2	3.0	1.2	6.1	-----	-----	-----
Chloride (mg/l)	1	19	11	11	8	12	860[2], 230[3], 250[4]	0	0%
Chemical Oxygen Demand (mg/l)	2	21	11	10	n.d.	24	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	38	444	450	310	542	1,750[4], 500[6]	0, 1	0%, 3%
Hardness, Total (mg/l)	0.4	2	220	220	211	229	-----	-----	-----
Iron, Dissolved (ug/l)	40	29	-----	n.d.	n.d.	246	1,000[3]	0	0%
Iron, Total (ug/l)	40	30	399	362	70	1,620	300[6]	18	60%
Kjeldahl N, Total (mg/l)	0.1	38	0.5	0.4	n.d.	1.6	-----	-----	-----
Manganese, Dissolved (ug/l)	1	29	14	5	n.d.	71	1,000[3]	0	0%
Manganese, Total (ug/l)	1	30	69	49	6	290	50[6]	15	50%
Nitrate-Nitrite N, Total (mg/l)	0.02	38	-----	n.d.	n.d.	0.60	10[4], 100[5]	0	0%
Phosphorus, Dissolved (mg/l)	0.01	18	-----	0.01	n.d.	0.17	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	38	0.07	0.05	n.d.	0.36	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	37	-----	n.d.	n.d.	0.09	-----	-----	-----
Sulfate (mg/l)	1	38	190	190	95	230	875[4], 250[6]	0	0%
Suspended Solids, Total (mg/l)	4	38	15	12	n.d.	45	158[2], 90[3]	0	0%
Aluminum, Dissolved (ug/l)	25	2	-----	n.d.	n.d.	26	750[2], 87[3]	0	0%
Antimony, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	0.6	88[2], 30[3]	0	0%
Arsenic, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	2	340[2], 16.7[3]	0	0%
Barium, Dissolved (ug/l)	5	1	44	44	44	44	1,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	3	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	6	-----	n.d.	n.d.	n.d.	12.7[2], 0.4[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	1,129[2], 147[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	6	8	9	n.d.	15	28.3[2], 17.6[3]	0	0%
Lead, Dissolved (ug/l)	0.5	6	-----	n.d.	n.d.	n.d.	151[2], 5 9[3]	0	0%
Mercury, Dissolved (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	0.77[3]	0	0%
Mercury, Total (ug/l)	0.02	7	-----	n.d.	n.d.	n.d.	1.8[2], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	n.d.	912[2], 101[3]	0	0%
Selenium, Total (ug/l)	1	5	-----	n.d.	n.d.	n.d.	20[2], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	6	-----	n.d.	n.d.	n.d.	13.4[2]	0	0%
Thallium, Dissolved (ug/l)	0.5	3	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	10	6	-----	n.d.	n.d.	13	230[2,3]	0	0%
Pesticide Scan (ug/l)***	0.05	4	-----	n.d.	n.d.	n.d.	****	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criteria for total dissolved solids, iron, and manganese are listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

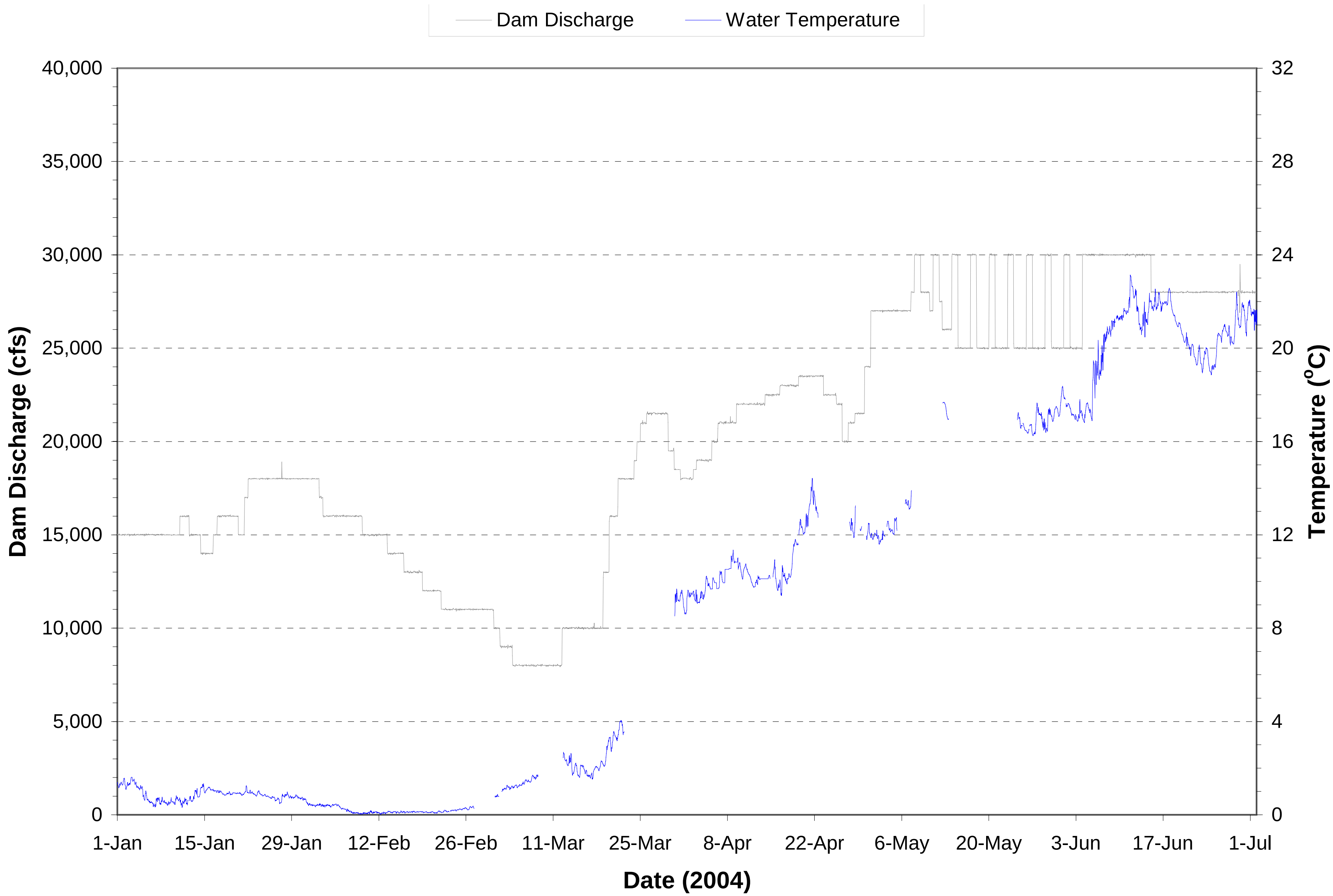


Plate 277. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

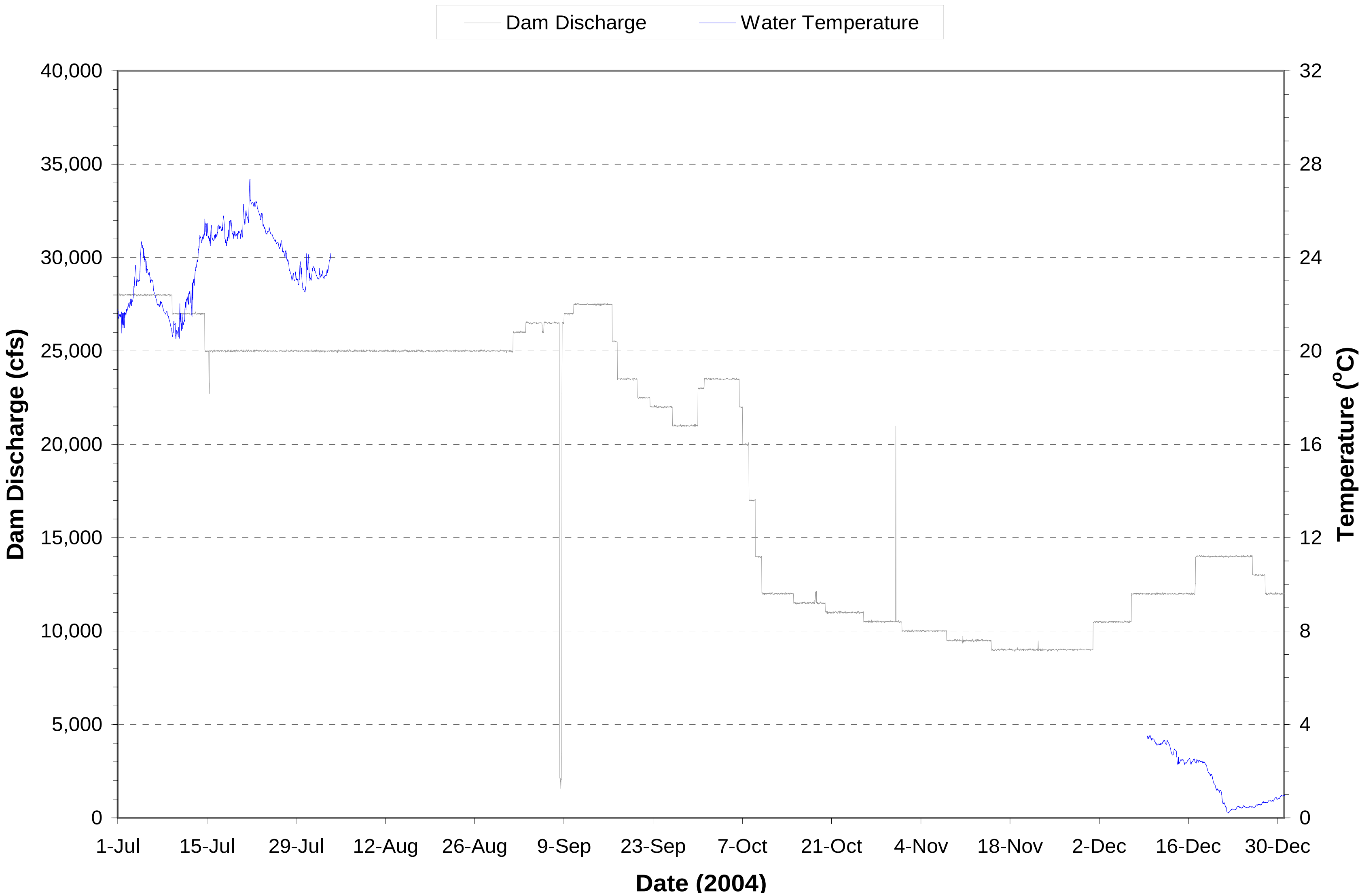


Plate 278. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

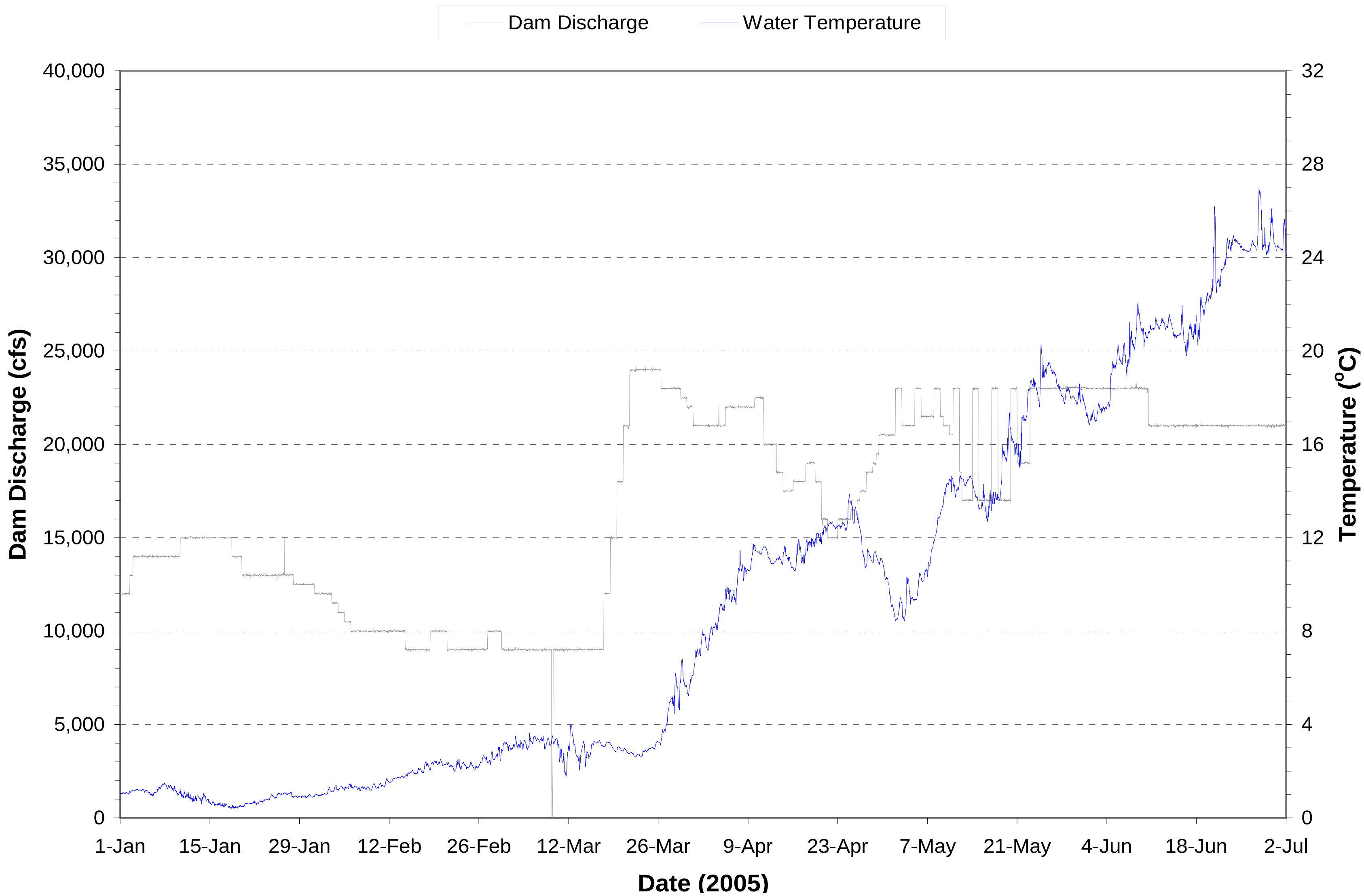


Plate 279. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

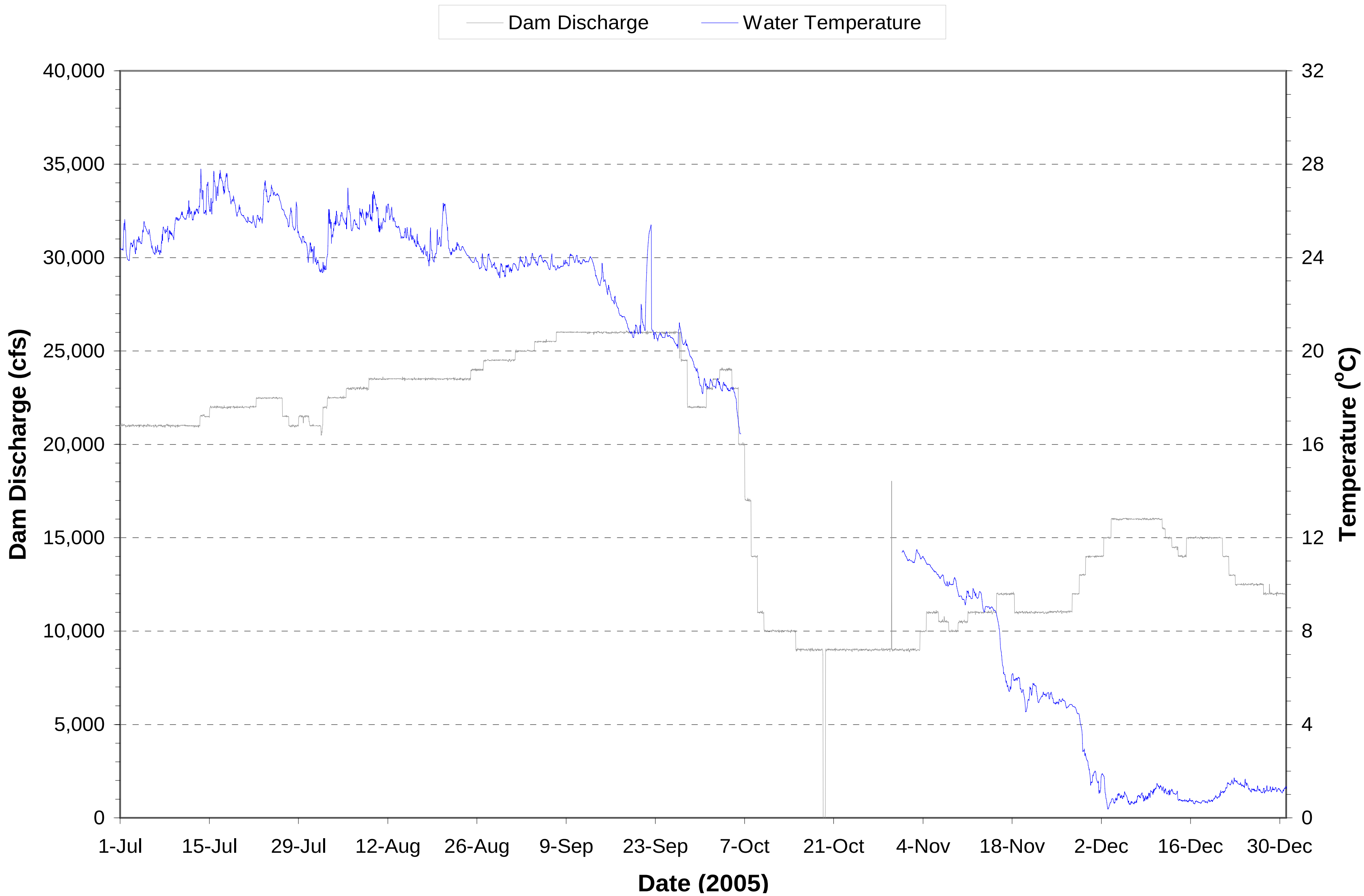


Plate 280. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

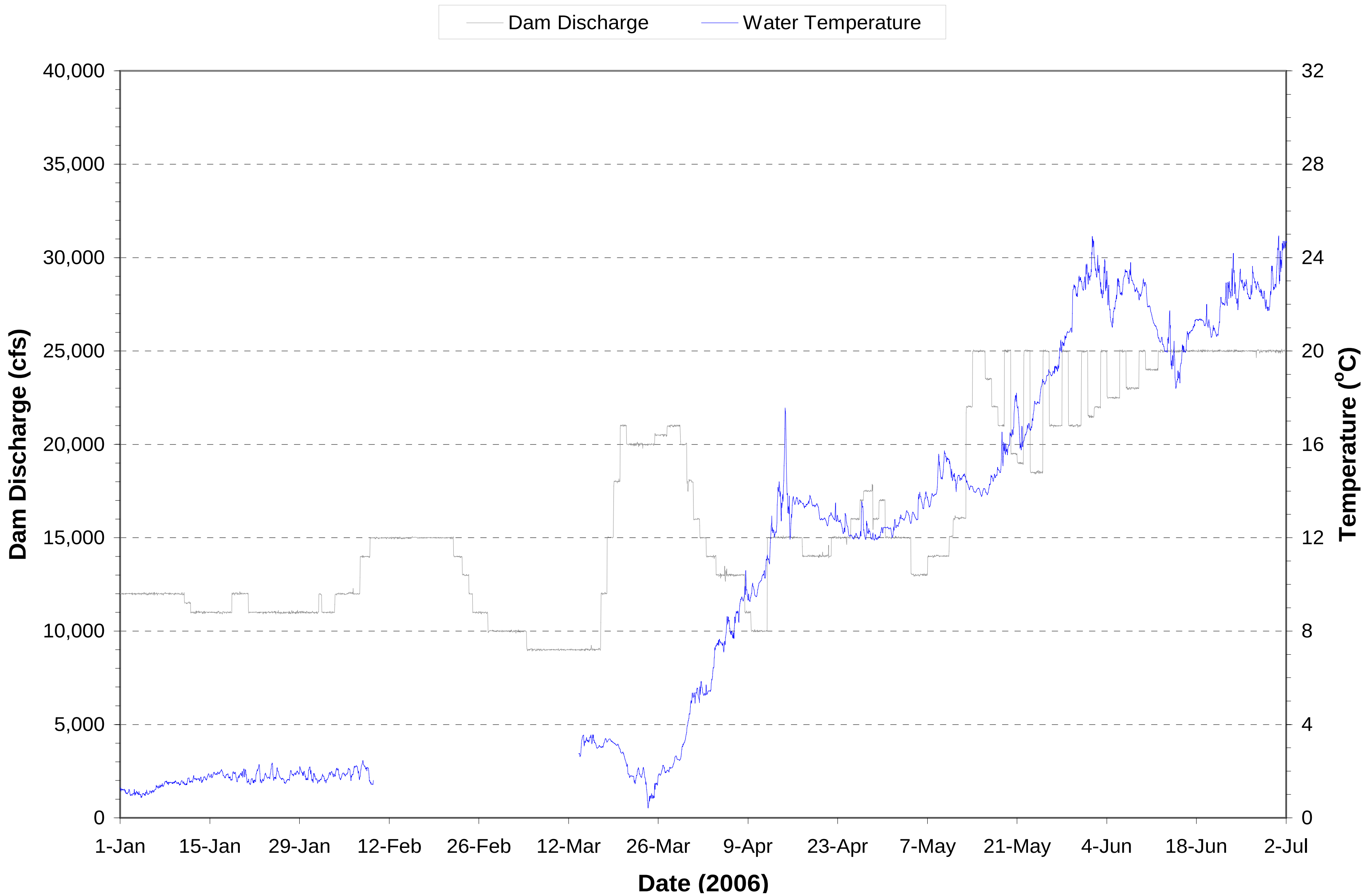


Plate 281. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

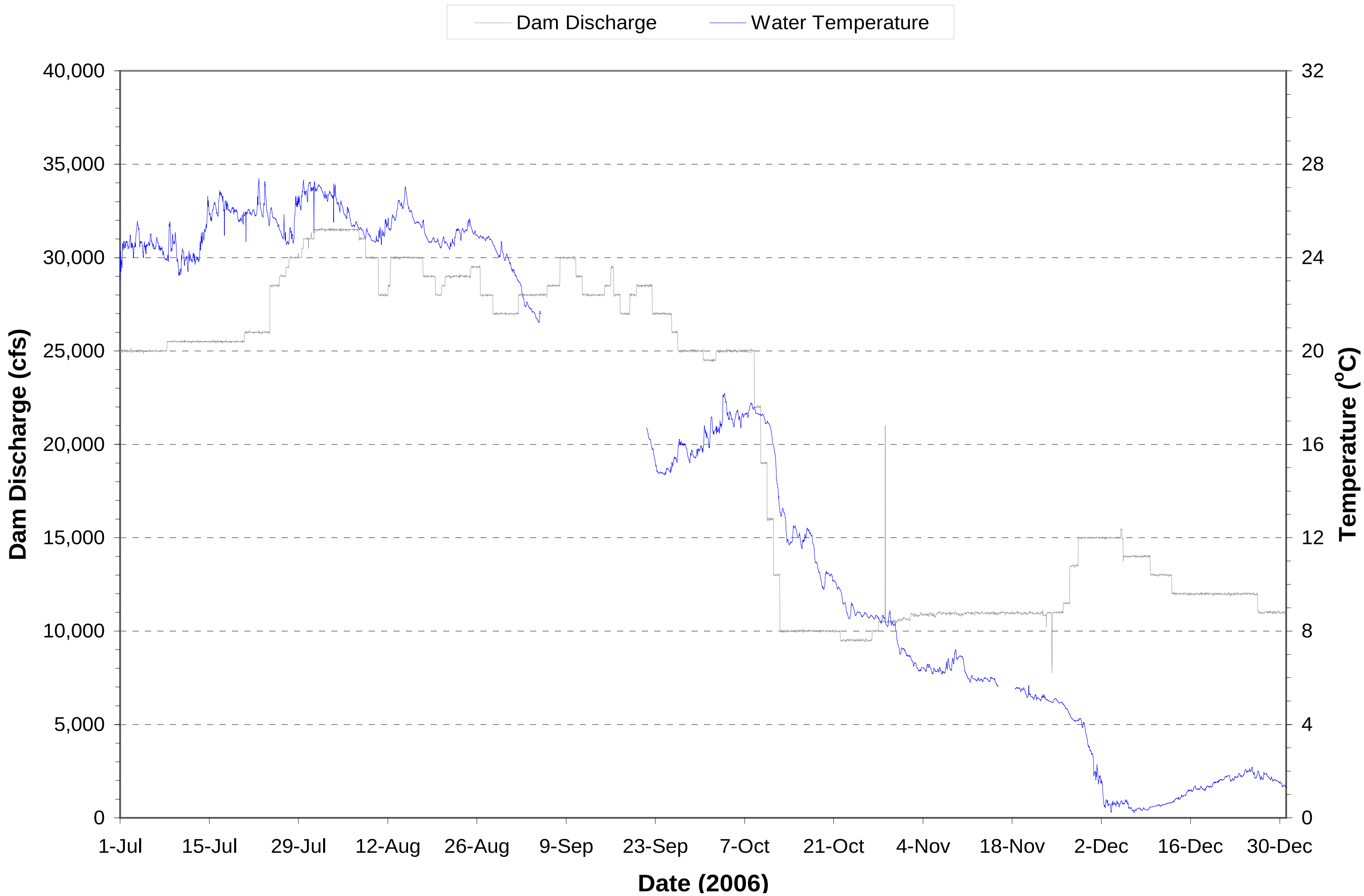


Plate 282. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

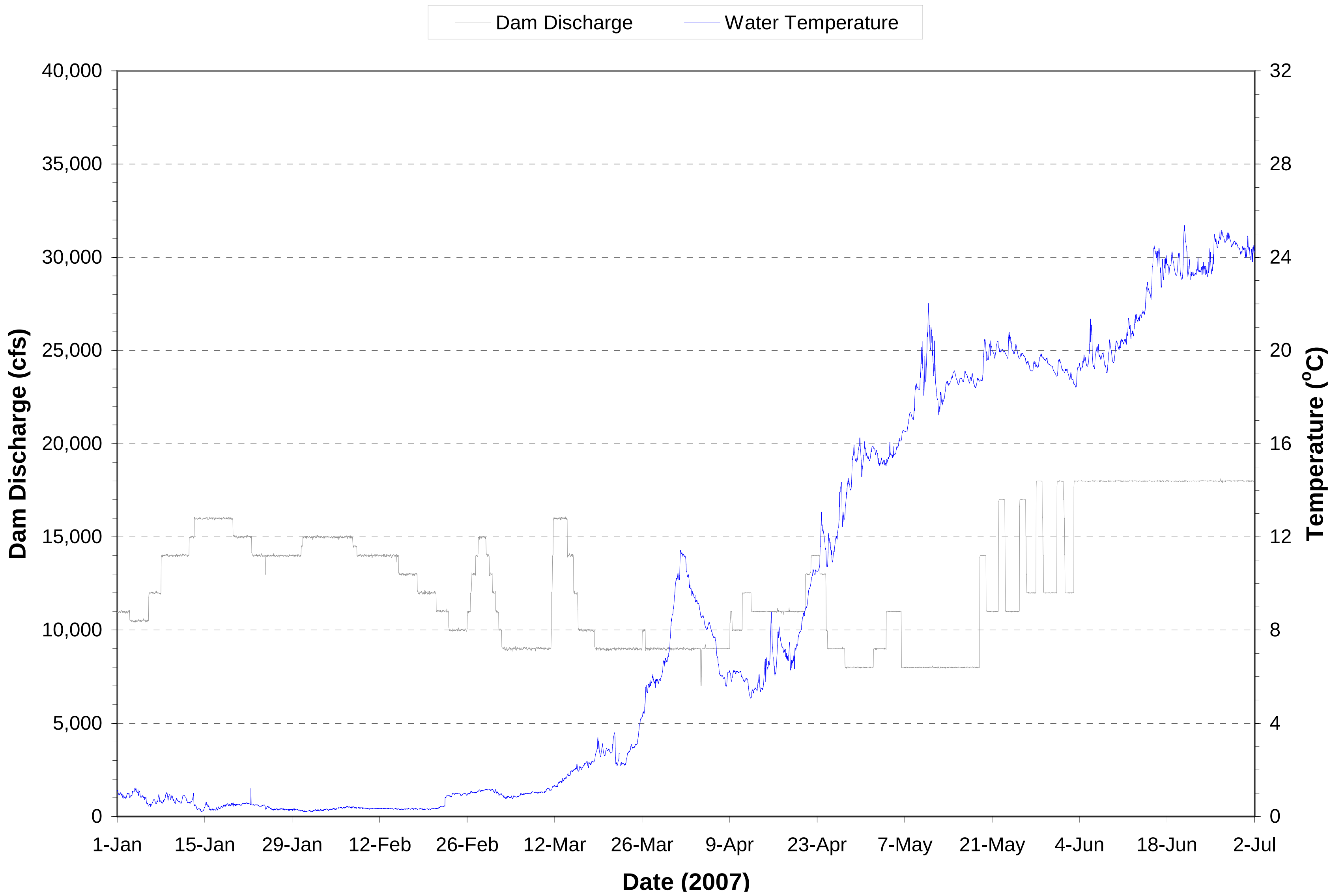


Plate 283. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2007.

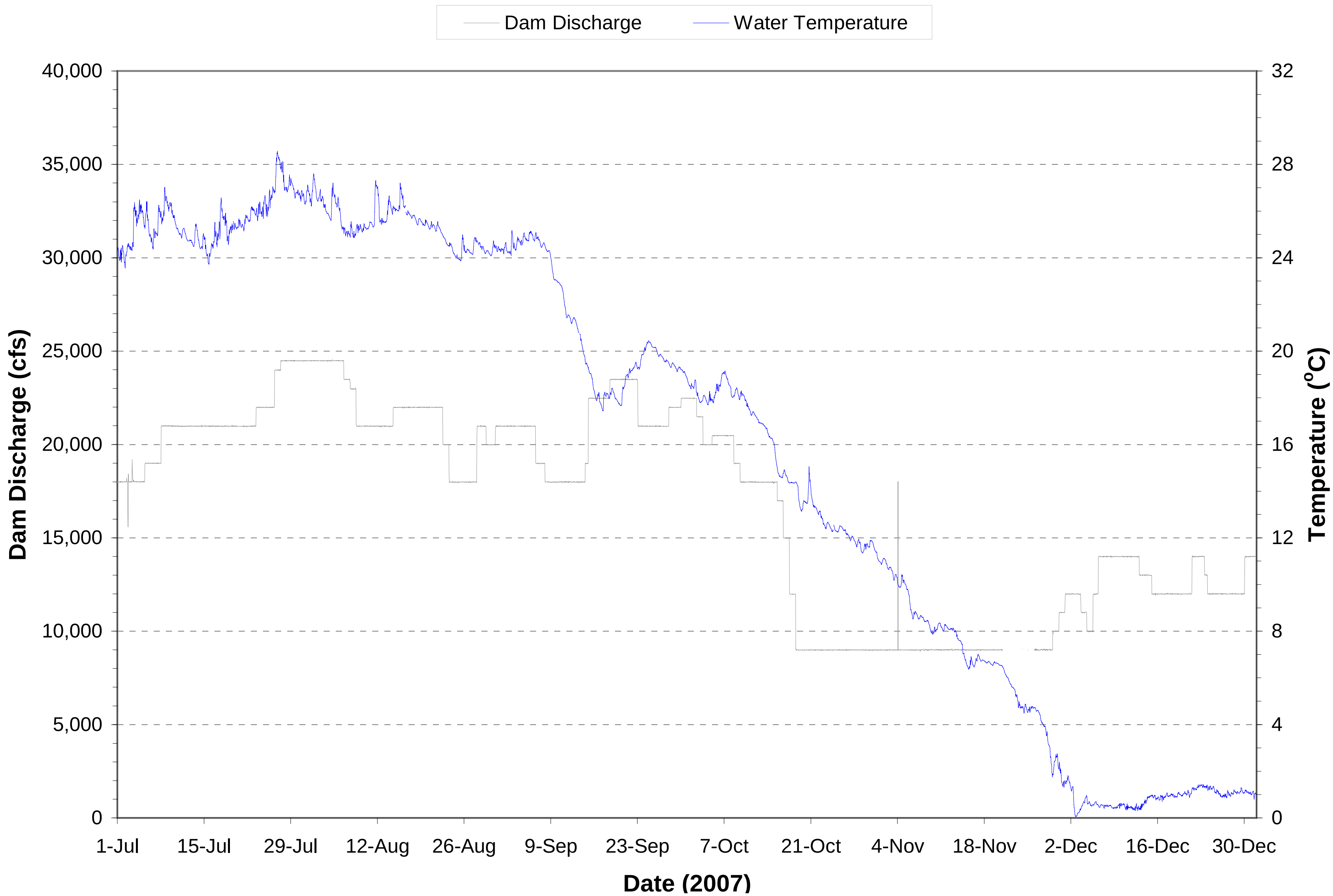


Plate 284. Hourly discharge and water temperature monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2007.

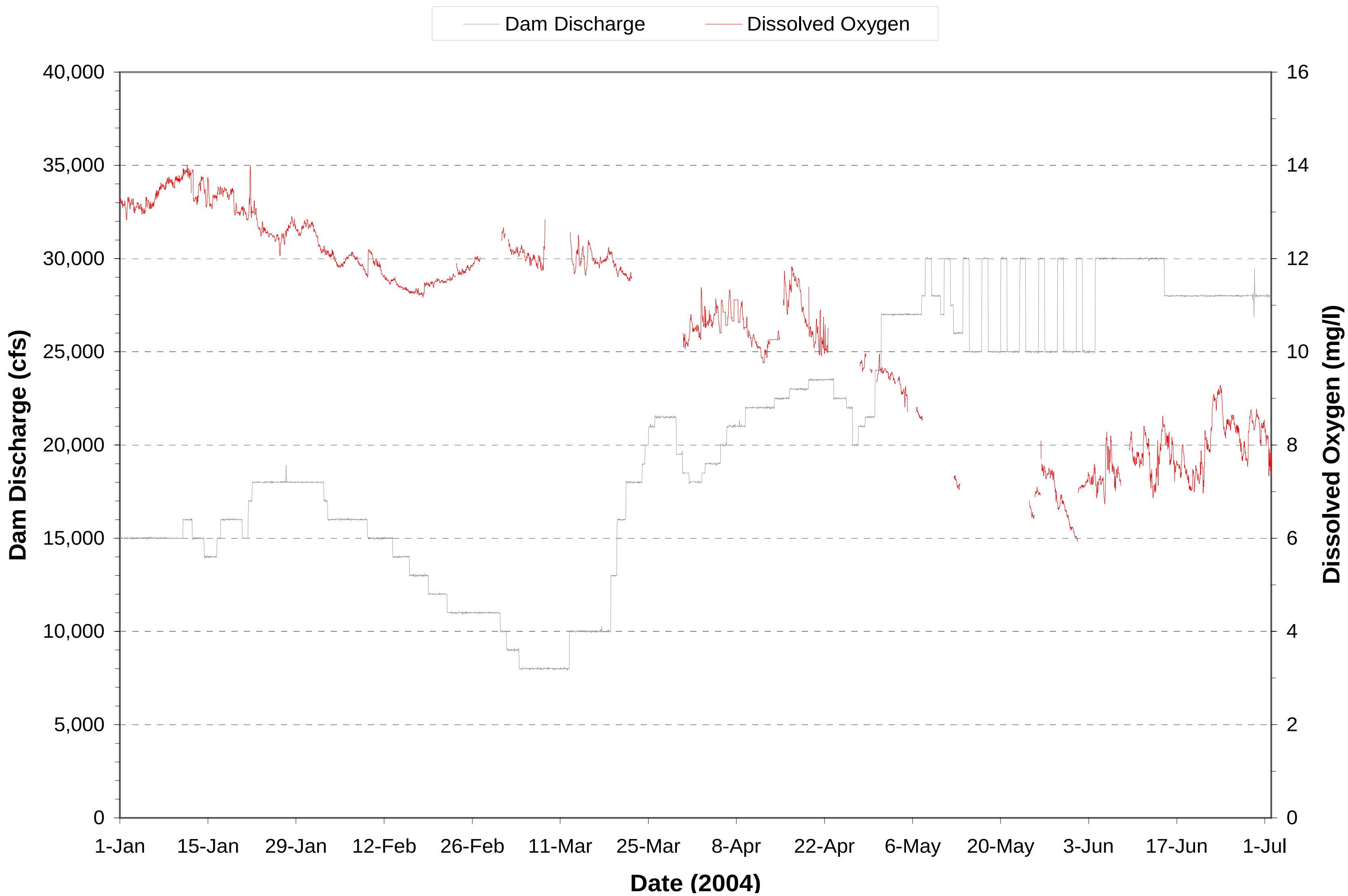


Plate 285. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

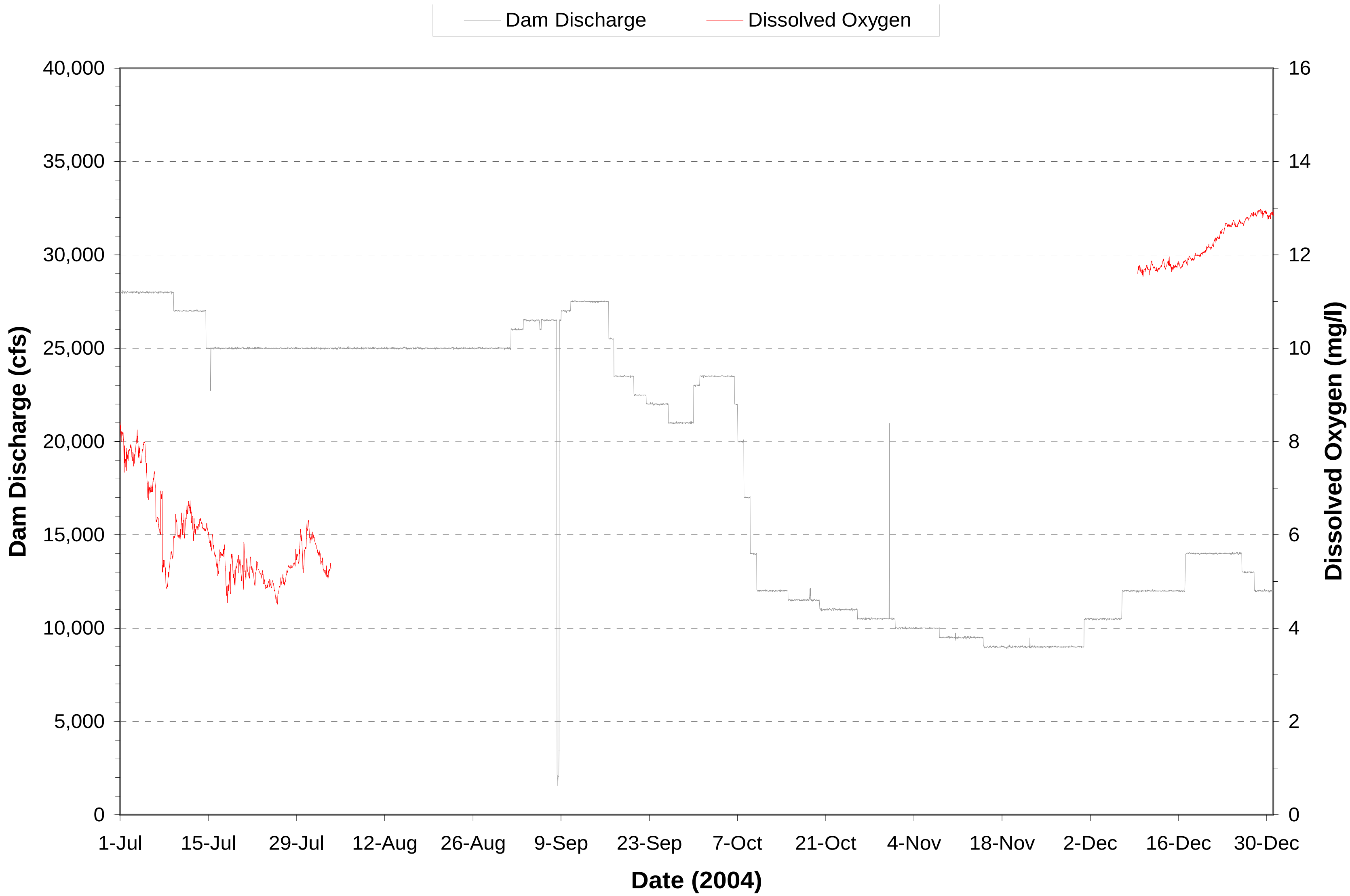


Plate 286. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2004. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

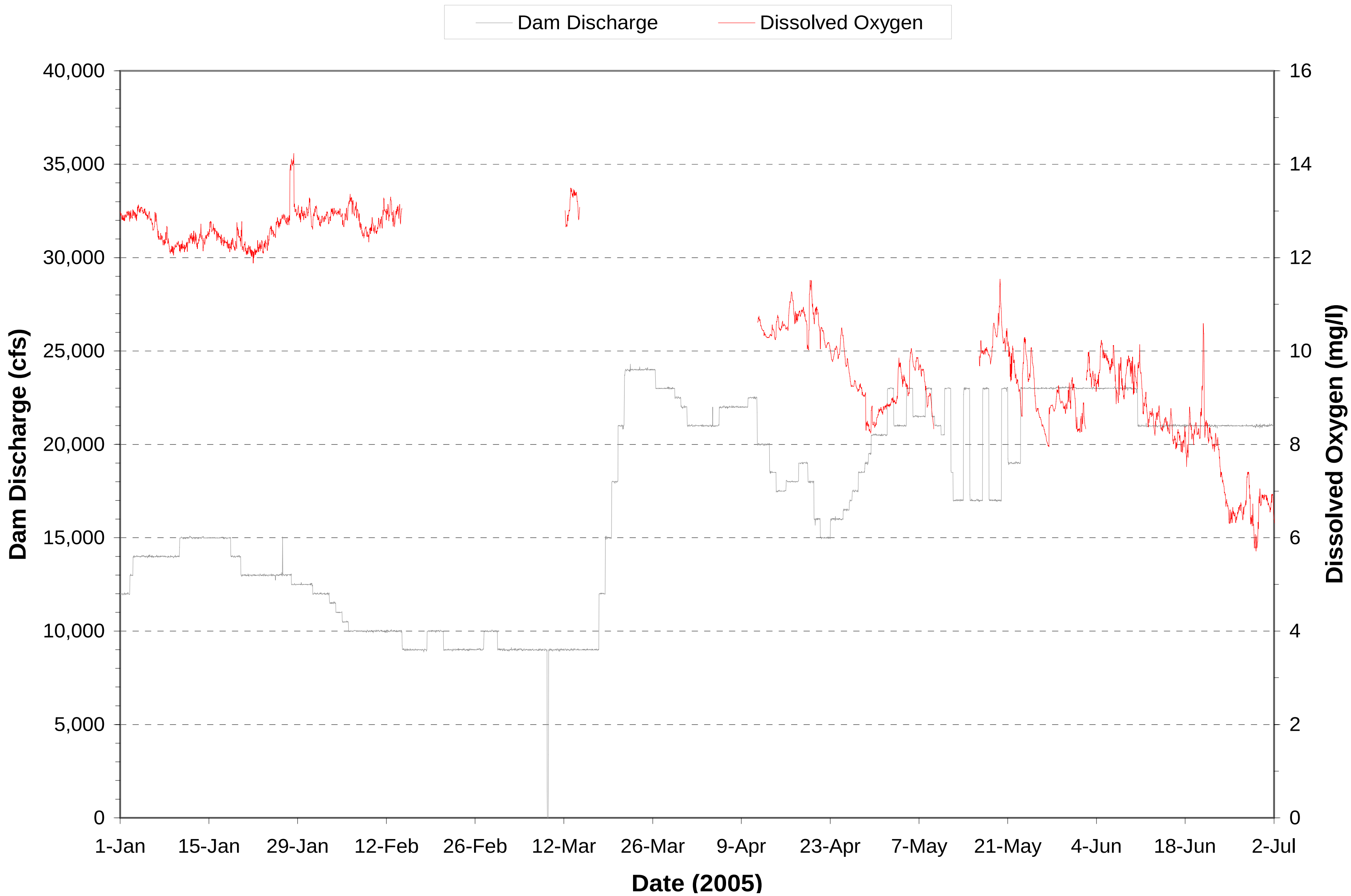


Plate 287. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

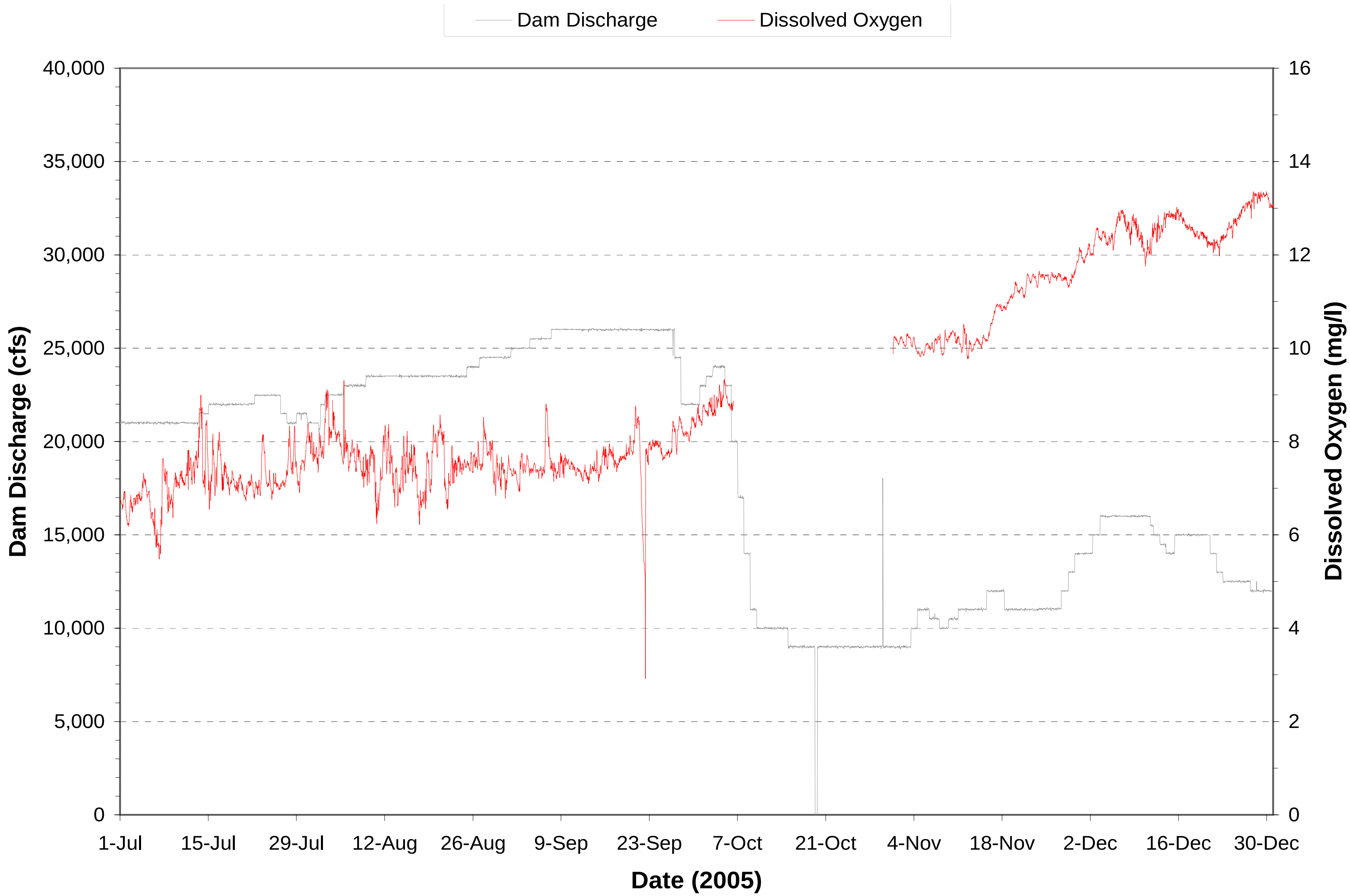


Plate 288. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2005. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

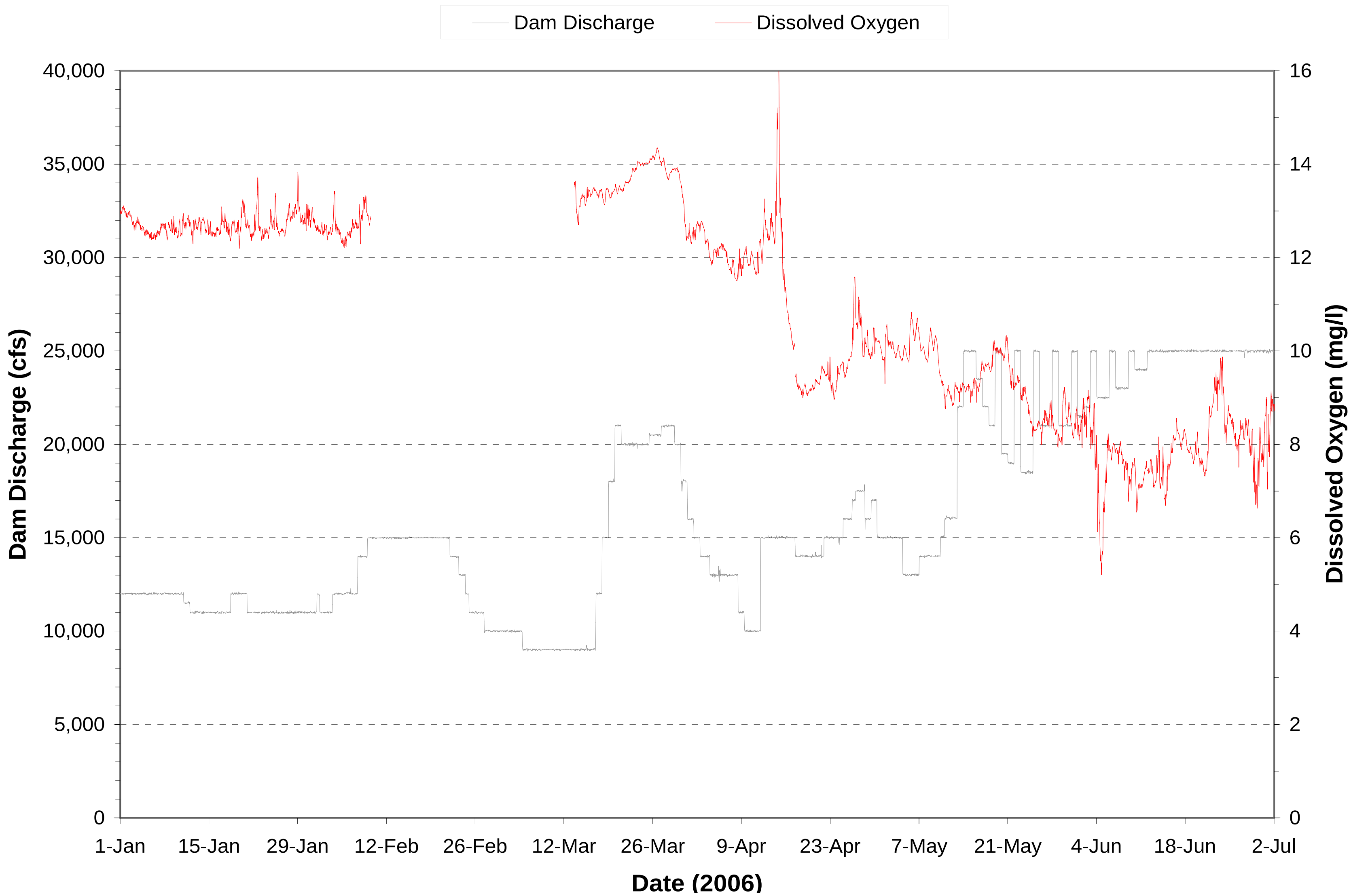


Plate 289. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

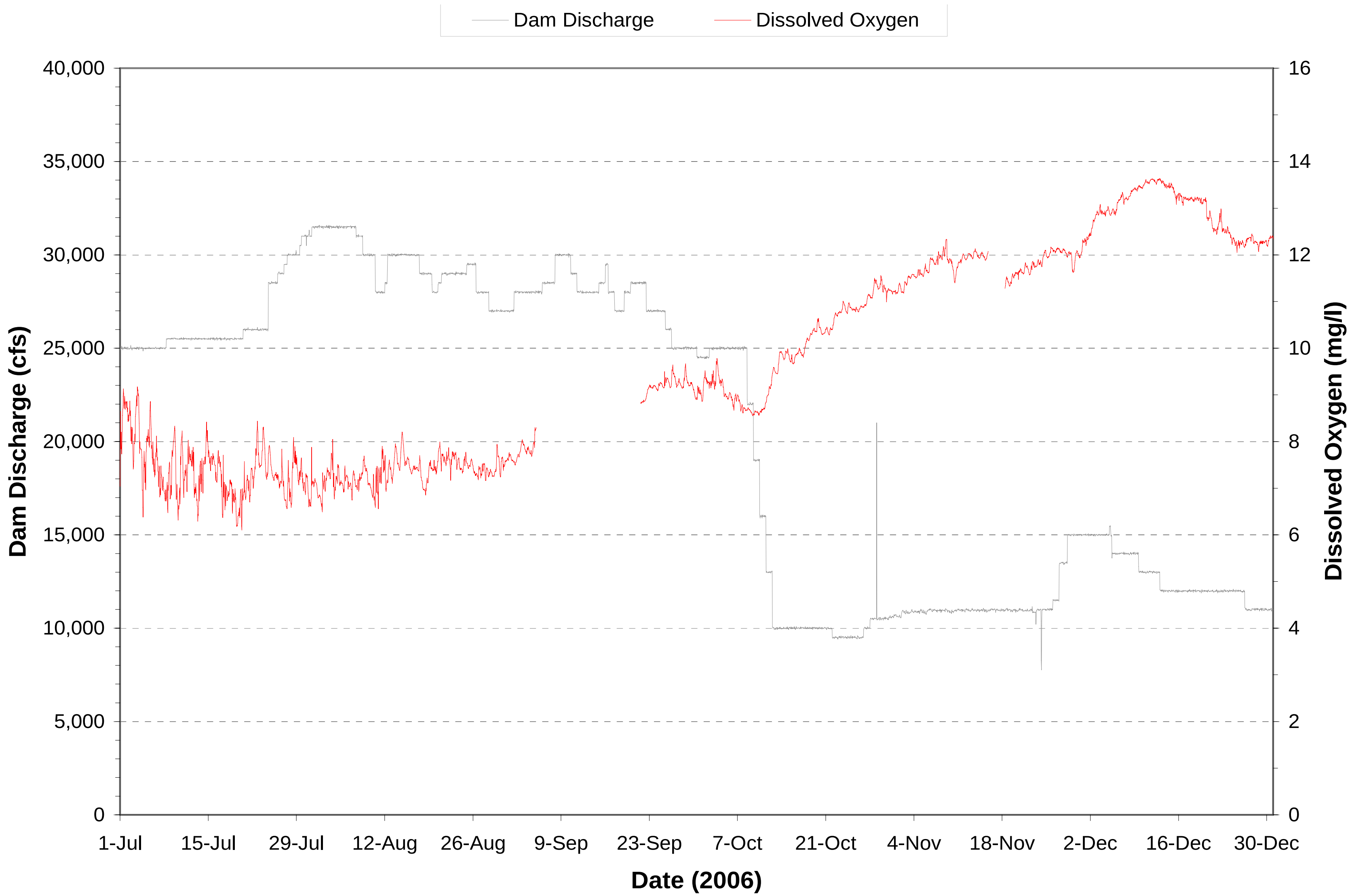


Plate 290. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2006. (Note: Gaps in temperature plot represents periods when monitoring equipment was not operational.)

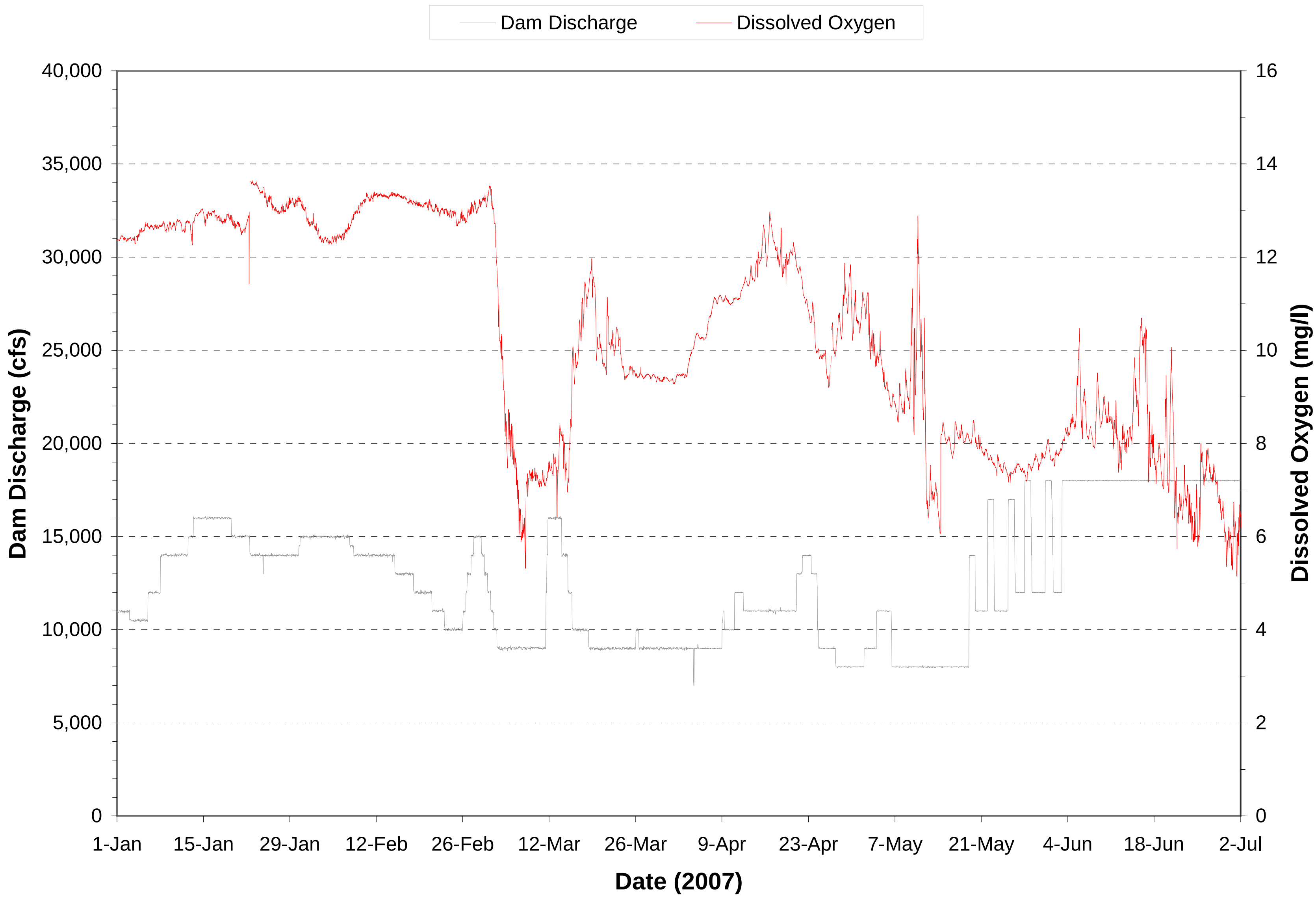


Plate 291. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period January through June 2007.

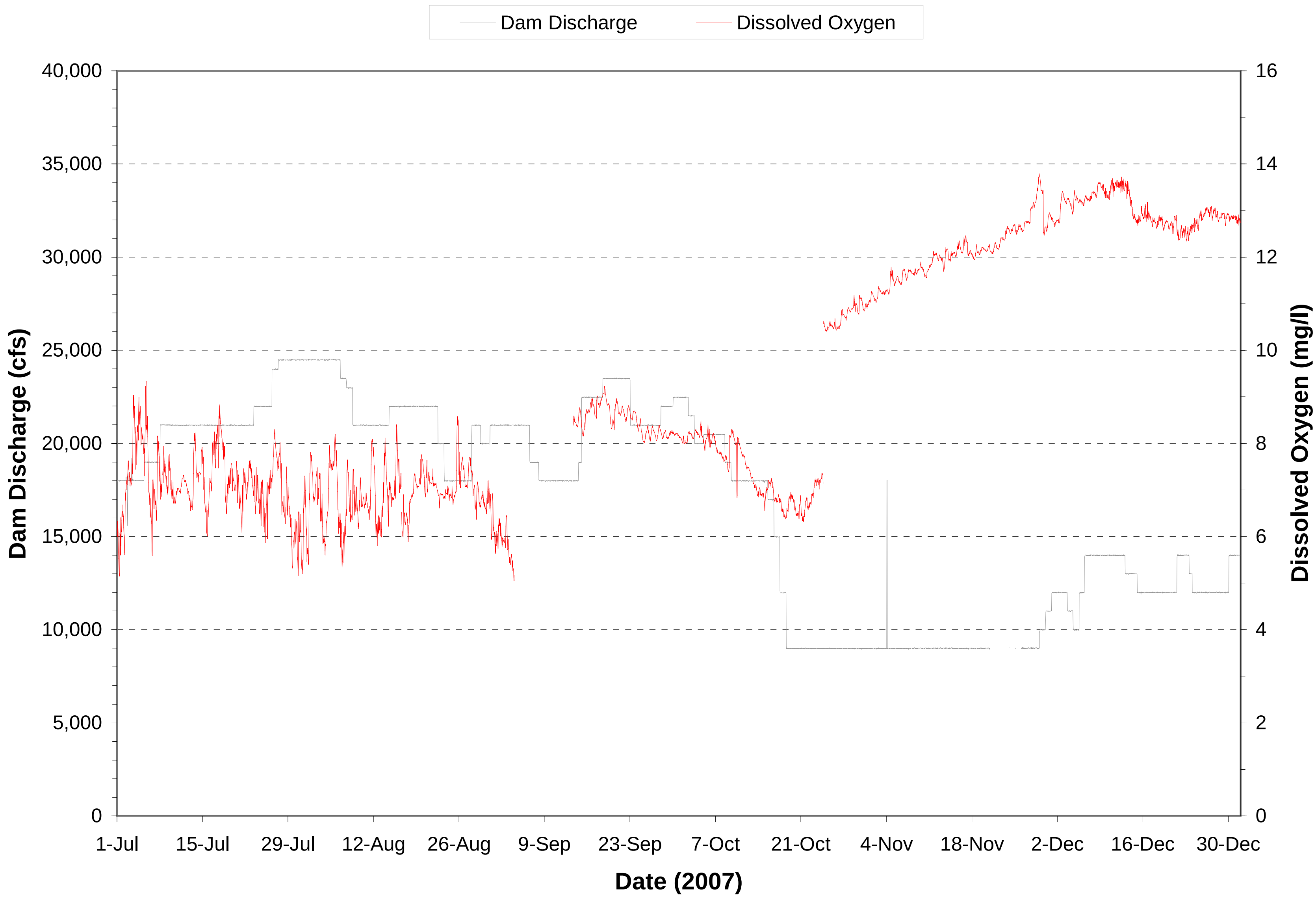


Plate 292. Hourly discharge and dissolved oxygen monitored at the Gavins Point powerplant on water discharged through the dam during the period July through December 2007. (Note: Gaps in dissolved oxygen plot represents periods when monitoring equipment was not operational.)

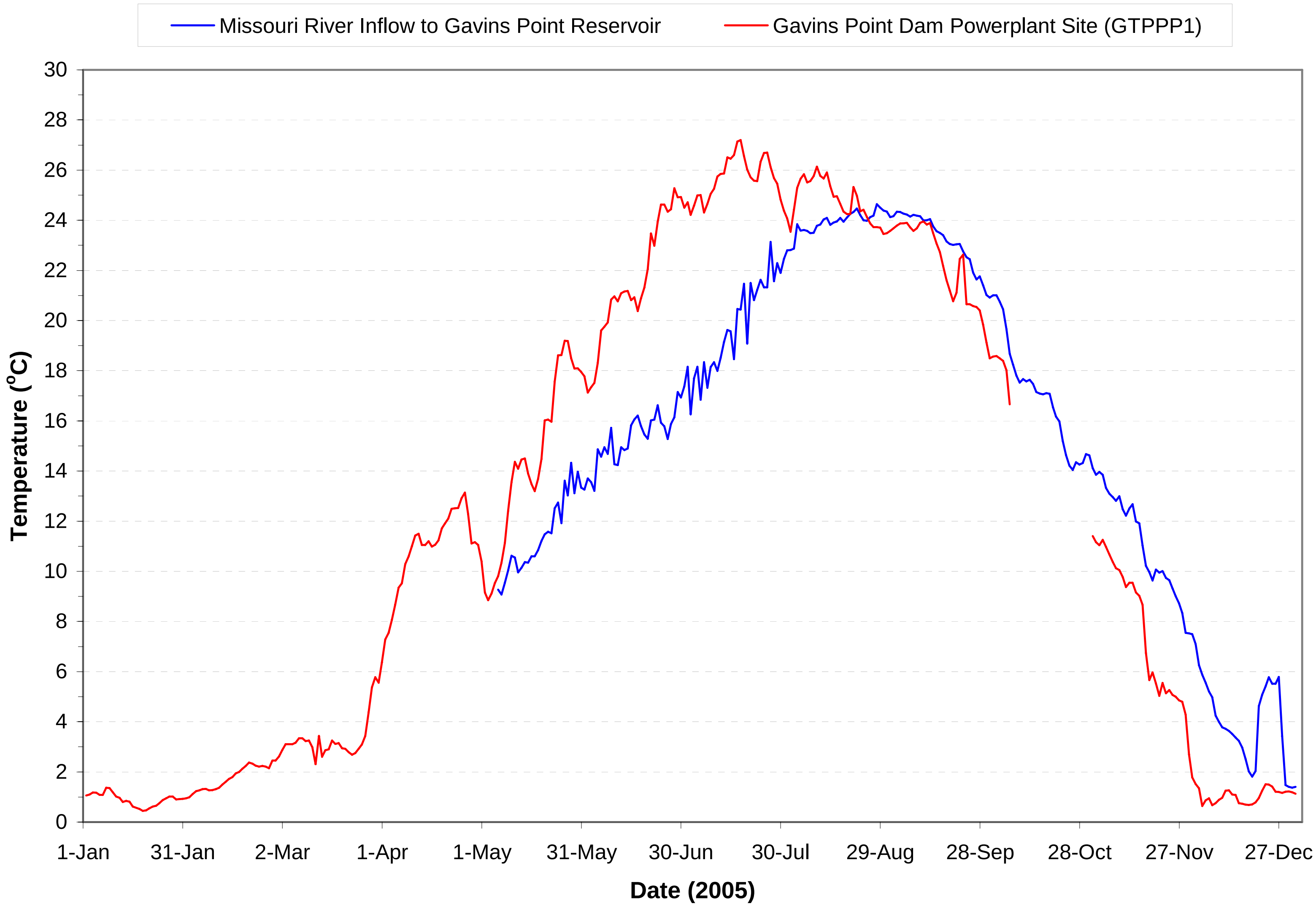


Plate 293. Mean daily water temperatures monitored at the Gavins Point Powerplant (i.e., site GTPPP1) and estimated for the Missouri River inflow to Gavins Point Reservoir during 2005. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

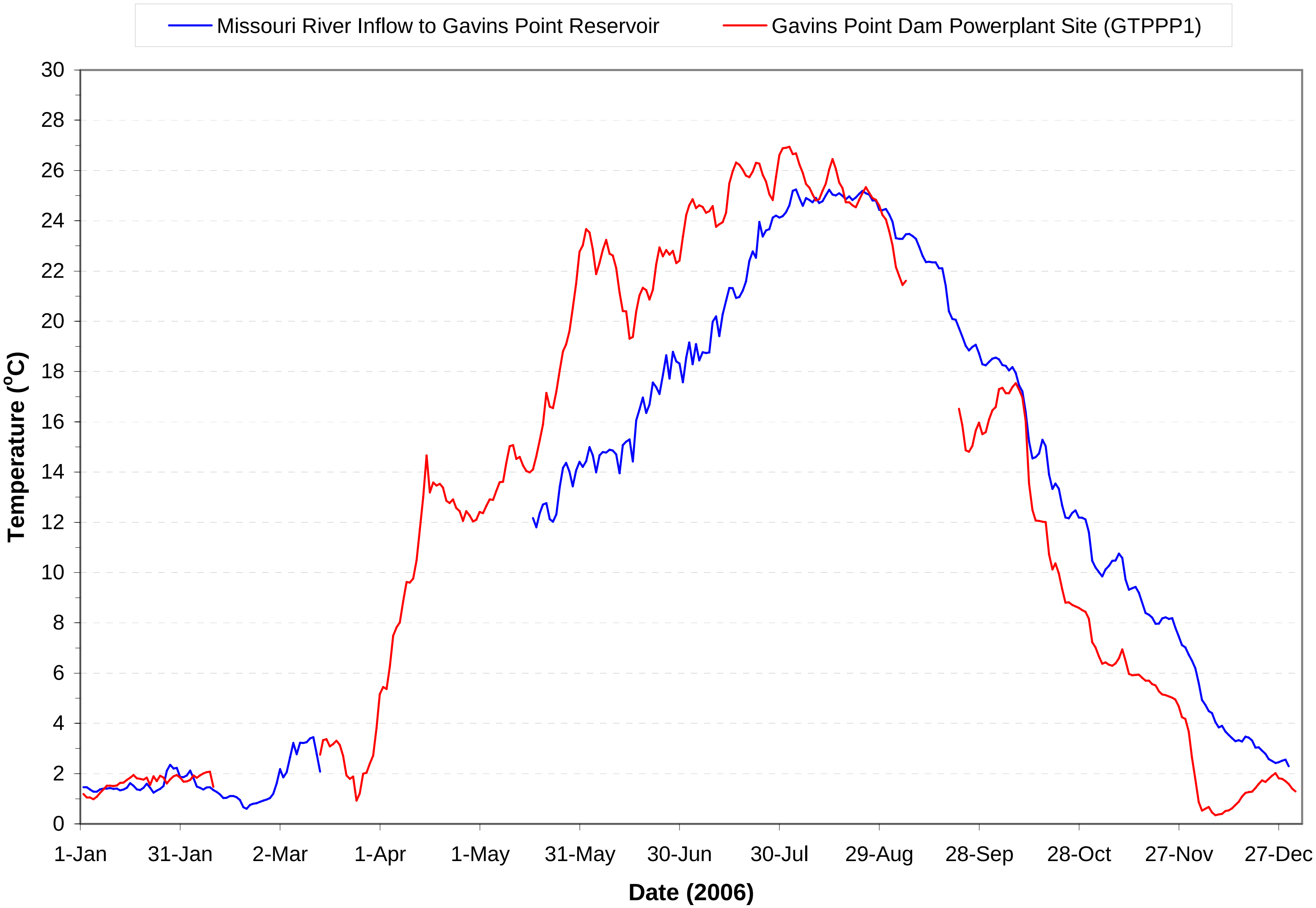


Plate 294. Mean daily water temperatures monitored at the Gavins Point Powerplant (i.e., site GTPPP1) and estimated for the Missouri River inflow to Gavins Point Reservoir during 2006. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

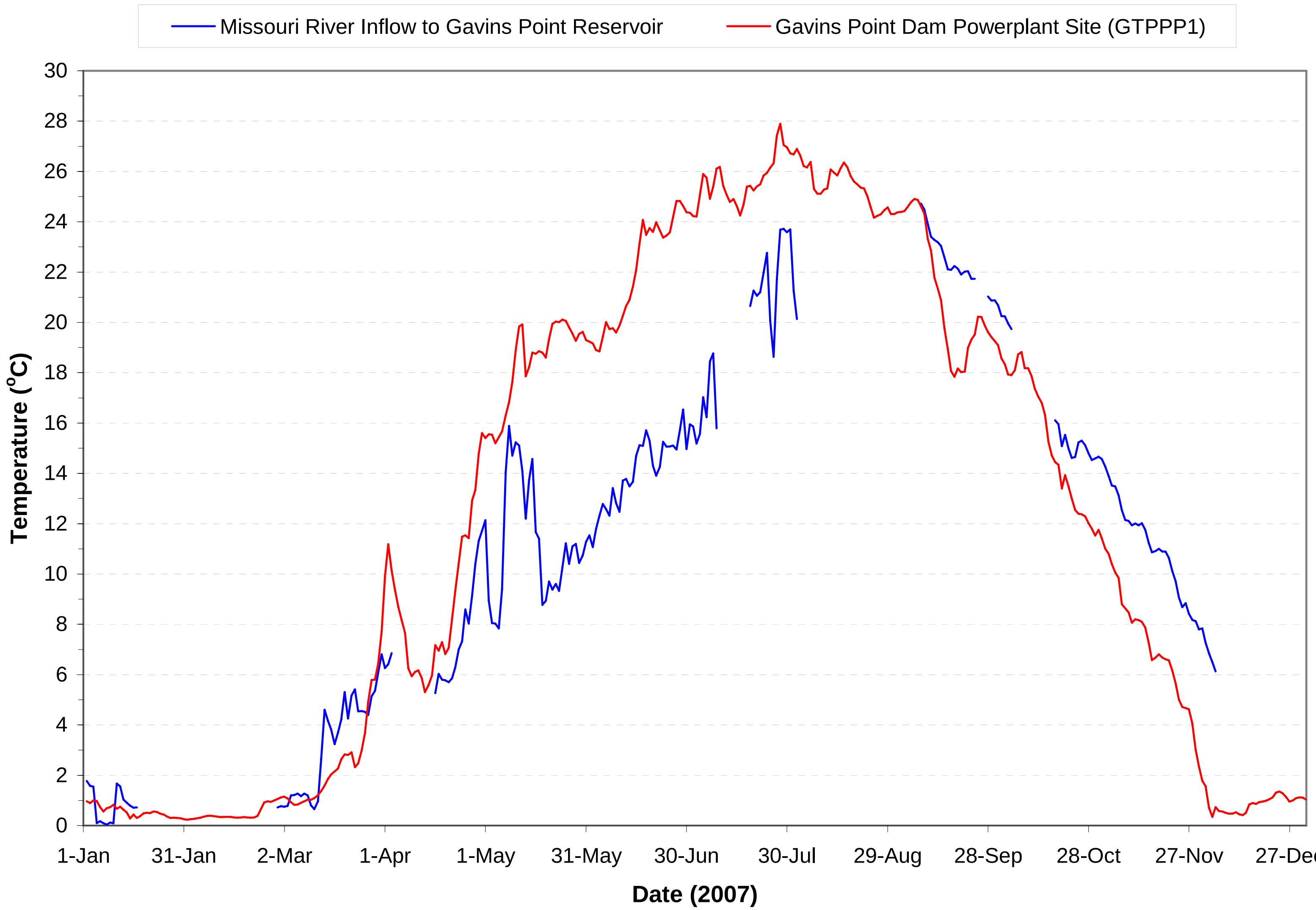


Plate 295. Mean daily water temperatures monitored at the Gavins Point Powerplant (i.e., site GTPPP1) and estimated for the Missouri River inflow to Gavins Point Reservoir during 2007. (Note: Gaps in temperature plots are periods when monitoring equipment was not operational.)

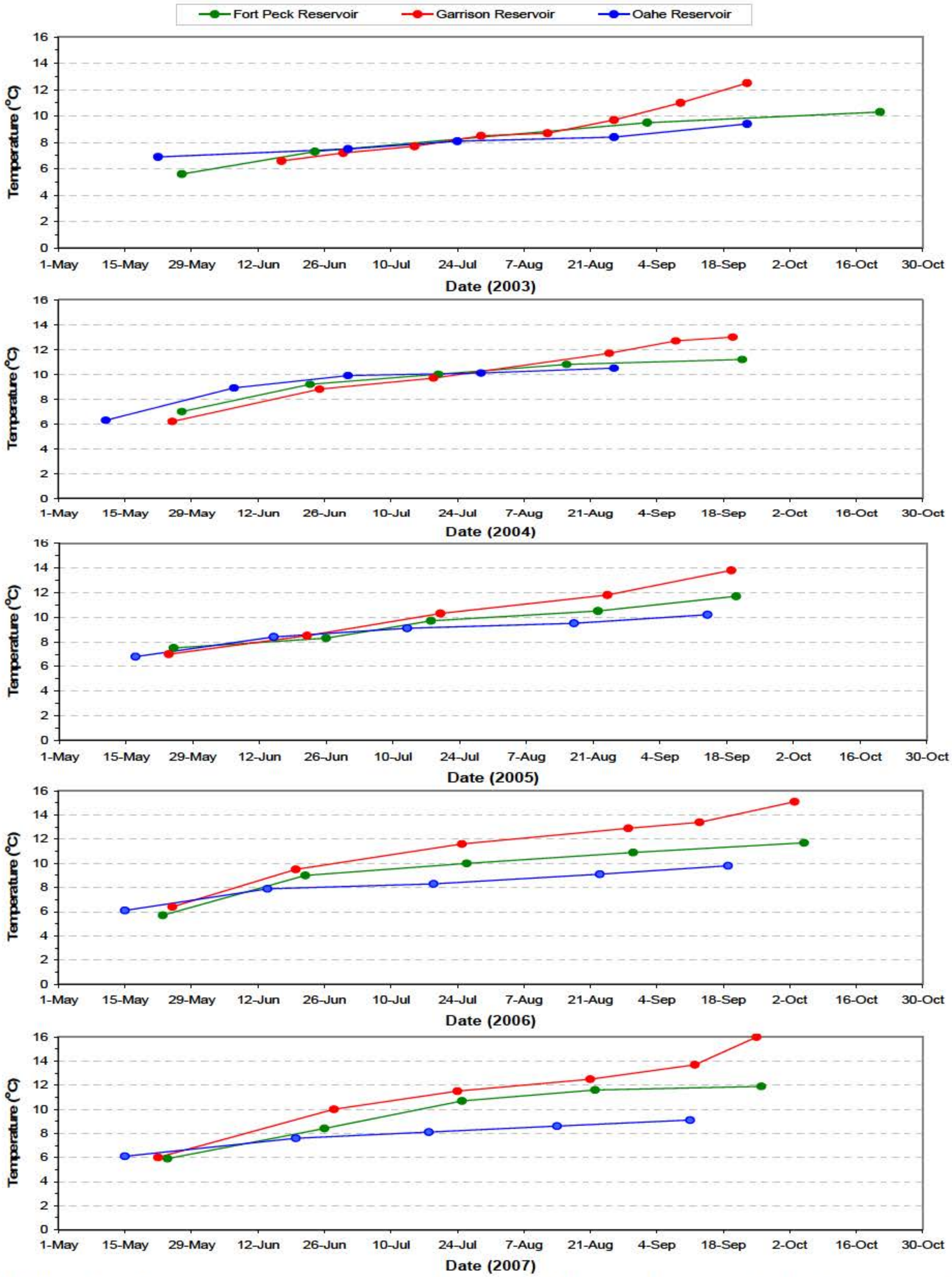


Plate 296. Near-bottom water temperatures measured at near-dam, deepwater locations in Fort Peck, Garrison, and Oahe Reservoirs during 2003 through 2006.

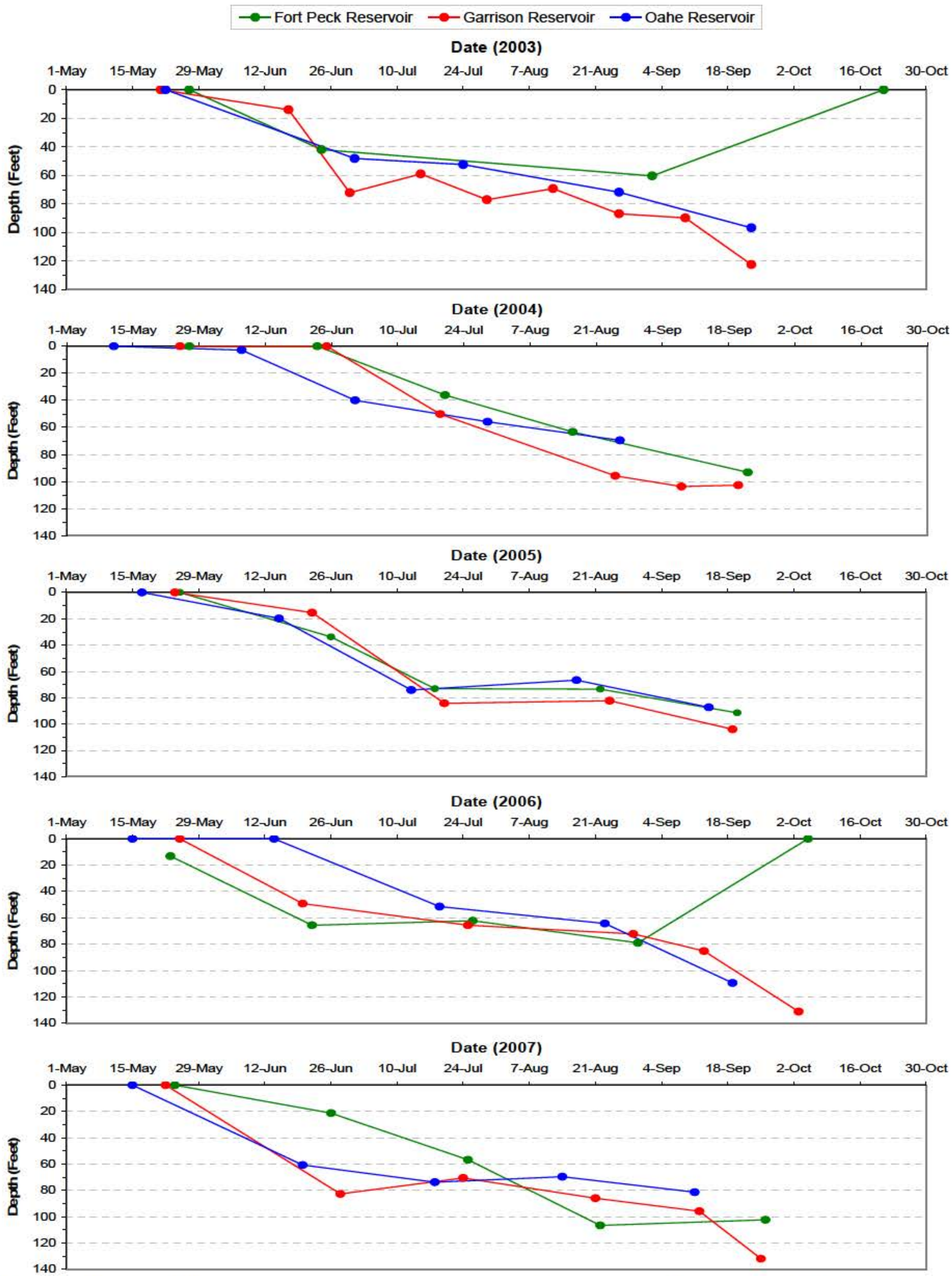


Plate 297. Depth to 15°C water temperature measured at near-dam, deepwater locations in Fort Peck, Garrison, and Oahe Reservoirs for the period 2003 through 2007.

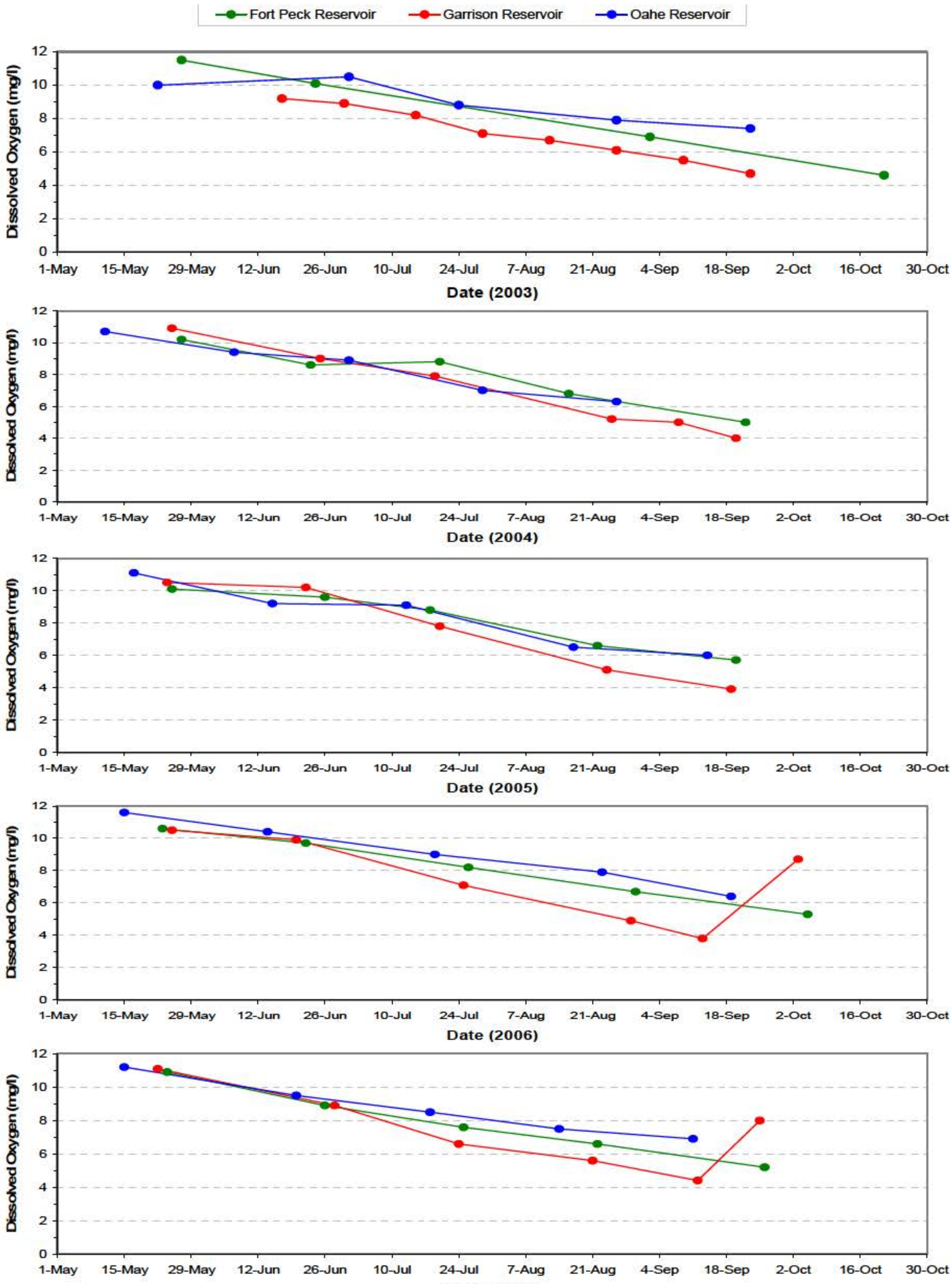


Plate 298. Near-bottom dissolved oxygen concentrations measured at near-dam, deepwater locations in Fort Peck, Garrison, and Oahe Reservoirs during 2003 through 2007.

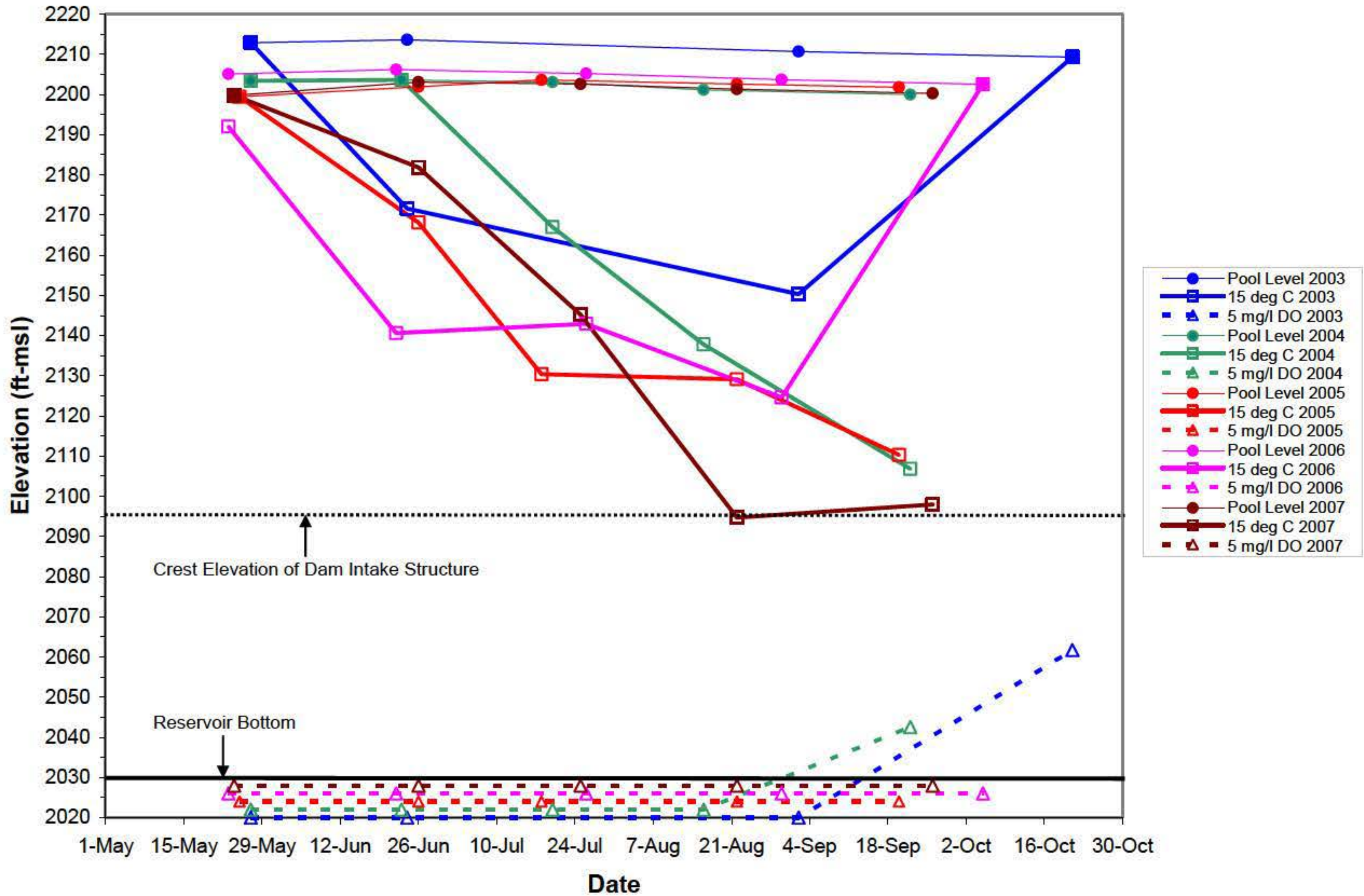


Plate 299. Elevation of the 15°C water temperature and 5 mg/l dissolved oxygen concentration isopleths for Fort Peck Reservoir based on water quality conditions monitored at a near-dam, deepwater location during 2003 through 2007. (Also shown are the reservoir pool elevation and the lower elevation of water withdrawal from the reservoir for power production.)

399

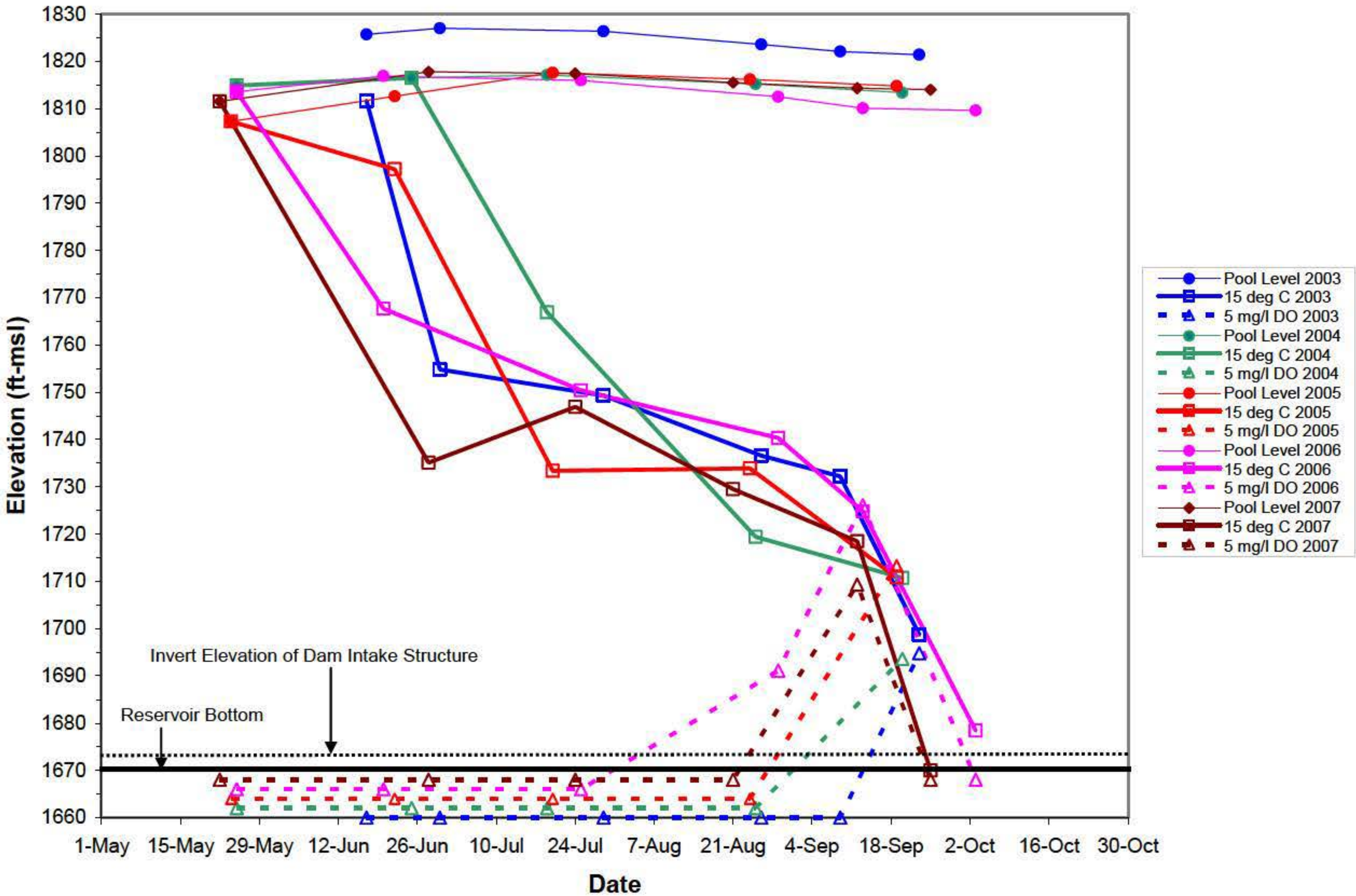


Plate 300. Elevation of the 15°C water temperature and 5 mg/l dissolved oxygen concentration isopleths for Garrison Reservoir based on water quality conditions monitored at a near-dam, deepwater location during 2003 through 2007. (Also shown are the reservoir pool elevation and the lower elevation of water withdrawal from the reservoir for power production.)

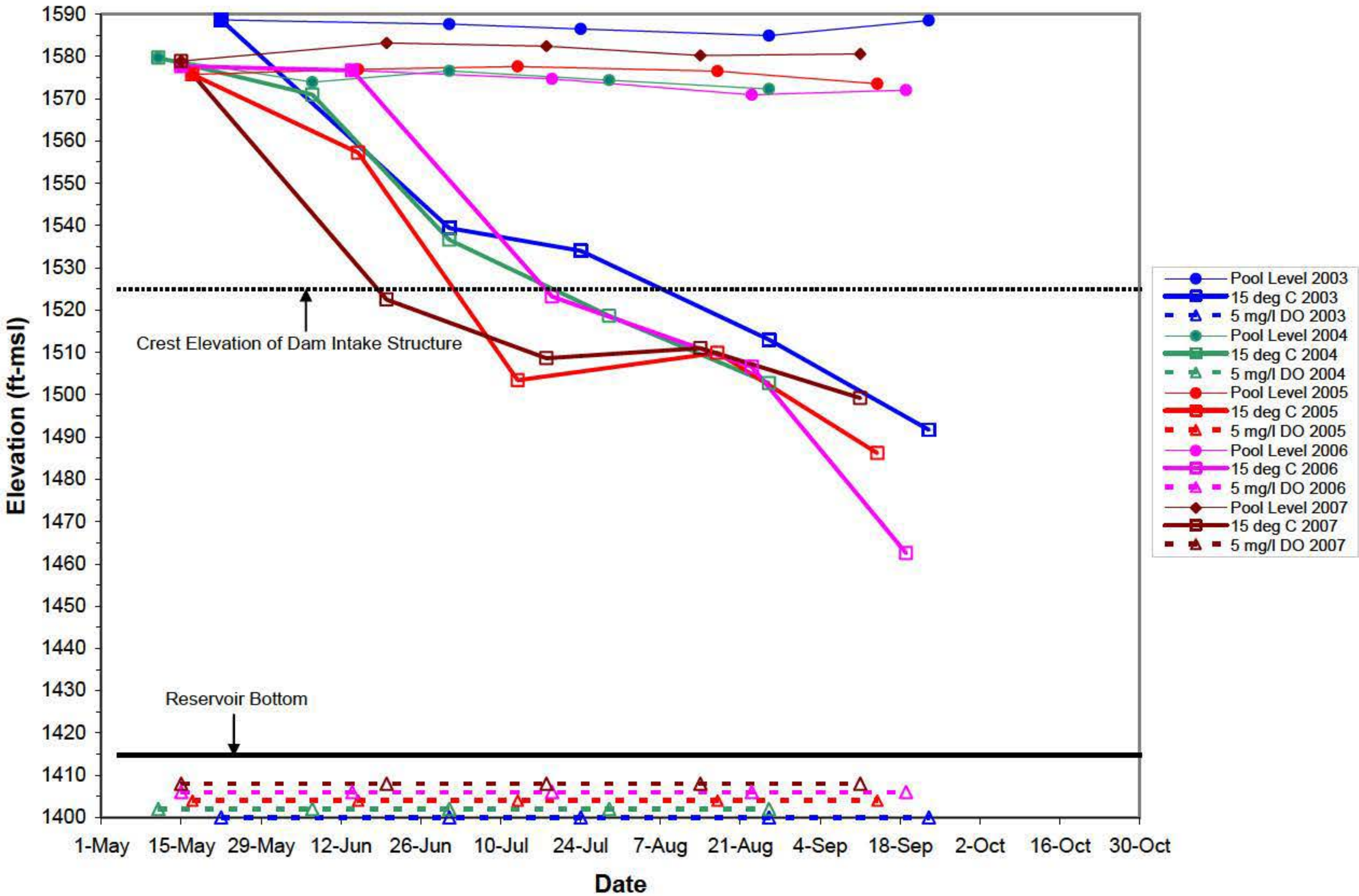


Plate 301. Elevation of the 15°C water temperature and 5 mg/l dissolved oxygen concentration isopleths for Oahe Reservoir based on water quality conditions monitored at a near-dam, deepwater location during 2003 through 2006. (Also shown are the reservoir pool elevation and the lower elevation of water withdrawal from the reservoir for power production.)

Plate 302. Summary of water quality conditions monitored in the Missouri River at the Gavins Point Dam tailwaters (i.e., site GPTRRTW1) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	84	20,291	21,987	8,000	30,963	-----	-----	-----
Water Temperature (C)	0.1	84	15.5	18.2	0.1	27.1	27.0 29.0	1 0	1% 0%
Dissolved Oxygen (mg/l)	0.1	84	9.5	89.0	5.9	14.7	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	84	95.3	95.5	60.5	117.8	-----	-----	-----
Specific Conductance (umho/cm)	1	84	655	656	466	756	2,000[5]	0	0%
pH (S.U.)	0.1	83	8.3	8.3	7.6	9.0	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential	1	28	384	386	308	472	-----	-----	-----
Alkalinity, Total (mg/l)	7	82	167	170	130	222	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	81	-----	0.08	n.d.	0.56	4.71 [1,2], 1.37 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	80	3.3	3.2	2.3	7.8	-----	-----	-----
Chloride (mg/l)	1	82	10	10	4	29	860[2], 230[3], 250[4]	0	0%
Chemical Oxygen Demand (mg/l)	2	82	9	8	n.d.	23	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	34	454	460	350	510	500[6]	1[6]	3%[6]
Hardness, Total (mg/l)	0.4	16	224	226	179	244	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	82	0.5	0.4	n.d.	2.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	81	-----	n.d.	n.d.	0.60	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	81	0.06	0.04	n.d.	1.10	-----	-----	-----
Suspended Solids, Total (mg/l)	4	82	11	10	n.d.	68	158[2], 90[3]	0	0%
Turbidity (NTU)	0.1	84	24.3	19.6	0.7	76.0	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	16	5	5	50	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	0.7	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	3	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	51	49	48	60	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	18	-----	n.d.	n.d.	n.d.	13.6[2], 0.45[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	18	-----	n.d.	n.d.	n.d.	1,196[2], 155[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	18	-----	n.d.	n.d.	21	30.2[2], 18.7[3], 1,000[4]	0, 1, 0	0%, 6%, 0%
Lead, Dissolved (ug/l)	0.5	18	-----	n.d.	n.d.	n.d.	162[2], 6.3[3], 15[4]	0	0%
Mercury, Dissolved (ug/l)	0.02	14	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	17	-----	n.d.	n.d.	n.d.	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	17	-----	n.d.	n.d.	n.d.	968[2], 108[3], 100[4]	0	0%
Selenium, Total (ug/l)	1	18	-----	n.d.	n.d.	4	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	18	-----	n.d.	n.d.	n.d.	15.1[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	18	-----	n.d.	n.d.	16	243[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	71	-----	n.d.	n.d.	0.07	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	71	-----	n.d.	n.d.	0.21	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)***	0.05	71	-----	n.d.	n.d.	0.13	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	13					*****	-----	-----
Atrazine, Total (ug/l)		13	-----	n.d.	n.d.	0.20	330[2], 12[3], 3[4]	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 303. Summary of water quality conditions monitored in the Missouri River near Maskell, Nebraska (i.e., site MORRR0774) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	80	21,954	23,997	9,161	31,082	-----	-----	-----
Water Temperature (C)	0.1	80	17.0	18.9	0.2	29.1	27.0 29.0	3 3	4% 4%
Dissolved Oxygen (mg/l)	0.1	80	9.5	8.8	6.0	14.7	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	80	99.2	99.1	68.7	121.0	-----	-----	-----
Specific Conductance (umho/cm)	1	80	671	679	471	766	2,000[5]	0	0%
pH (S.U.)	0.1	79	8.4	8.4	7.6	9.0	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential	1	25	379	379	297	456	-----	-----	-----
Alkalinity, Total (mg/l)	7	82	171	170	135	221	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	81	-----	0.08	n.d.	0.68	3.88 [1,2], 0.97 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	80	3.4	3.3	1.7	6.6	-----	-----	-----
Chloride (mg/l)	1	82	11	10	4	45	860[2], 230[3], 250[4]	0	0%
Chemical Oxygen Demand (mg/l)	2	82	11	11	n.d.	27	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	32	476	470	422	540	500[6]	7[6]	22%[6]
Hardness, Total (mg/l)	0.4	17	242	238	216	342	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	82	0.6	0.5	n.d.	2.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	82	-----	0.06	n.d.	1.30	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	81	0.08	0.05	n.d.	0.40	-----	-----	-----
Suspended Solids, Total (mg/l)	4	82	35	20	n.d.	320	158[2], 90[3]	3, 8	4%, 10%
Turbidity (NTU)	0.1	79	39.8	24.3	3.3	352.7	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	-----	n.d.	n.d.	60	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	0.6	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	16	-----	n.d.	n.d.	3	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	55	56	48	62	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	14	-----	n.d.	n.d.	n.d.	13.7[2], 0.45[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	16	-----	n.d.	n.d.	n.d.	1,204[2], 157[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	15	-----	n.d.	n.d.	3	30.4[2], 18.8[3], 1,000[4]	0	0%
Lead, Dissolved (ug/l)	0.5	16	-----	n.d.	n.d.	n.d.	164[2], 6.3[3], 15[4]	0	0%
Mercury, Dissolved (ug/l)	0.02	14	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	17	-----	n.d.	n.d.	n.d.	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	16	-----	n.d.	n.d.	n.d.	975[2], 108[3], 100[4]	0	0%
Selenium, Total (ug/l)	1	16	-----	n.d.	n.d.	4.	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	16	-----	n.d.	n.d.	n.d.	15.3[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	16	-----	n.d.	n.d.	97	244[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	73	-----	n.d.	n.d.	0.13	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	73	-----	n.d.	n.d.	3.70	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)***	0.05	73	-----	n.d.	n.d.	0.50	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	11					*****	-----	-----
Acetochlor, Total (ug/l)		11	-----	n.d.	n.d.	0.30	-----	-----	-----
Atrazine, Total (ug/l)		11	-----	n.d.	n.d.	0.20	330[2], 12[3], 3[4]	0	0%
Profluralin, Total (ug/l)		5	-----	n.d.	n.d.	0.17	-----	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 304. Summary of water quality conditions monitored in the Missouri River near Ponca, Nebraska (i.e., site MORRR0753) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	80	21,991	23,825	9,247	31,661	-----	-----	-----
Water Temperature (C)	0.1	80	16.6	19.1	0.2	29.5	27.0 29.0	3 1	4% 1%
Dissolved Oxygen (mg/l)	0.1	80	9.5	8.8	7.3	14.3	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	80	99.3	99.3	60.8	125.2	-----	-----	-----
Specific Conductance (umho/cm)	1	80	684	688	469	792	2,000[5]	0	0%
pH (S.U.)	0.1	79	8.4	8.4	7.7	9.0	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential	1	28	384	386	288	474	-----	-----	-----
Alkalinity, Total (mg/l)	7	79	170	171	127	218	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	78	-----	0.06	n.d.	0.45	3.88 [1,2], 0.96 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	76	3.7	3.4	2.4	8.9	-----	-----	-----
Chloride (mg/l)	1	79	11	11	4	26	860[2], 230[3], 250[4]	0	0%
Chemical Oxygen Demand (mg/l)	2	79	13	11	n.d.	56	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	34	503	495	316	606	500[6]	15[6]	44%[6]
Hardness, Total (mg/l)	0.4	17	243	243	225	279	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	79	0.7	0.5	n.d.	4.3	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	79	-----	0.02	n.d.	0.90	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	78	0.12	0.07	n.d.	0.73	-----	-----	-----
Suspended Solids, Total (mg/l)	4	79	49	26	n.d.	498	158[2], 90[3]	5, 6	6%, 8%
Turbidity (NTU)	0.1	79	57.3	26.1	3.5	975.4	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	-----	n.d.	n.d.	n.d.	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	0.7	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	17	-----	n.d.	n.d.	3	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	56	58	48	60	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	17	-----	n.d.	n.d.	n.d.	14.0[2], 0.46[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	17	-----	n.d.	n.d.	n.d.	1,225[2], 159[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	17	-----	n.d.	n.d.	24	31.0[2], 19.1[3], 1,000[4]	0, 1, 0	0%, 6%, 0%
Lead, Dissolved (ug/l)	0.5	16	-----	n.d.	n.d.	n.d.	167[2], 6.5[3], 15[4]	0	0%
Mercury, Dissolved (ug/l)	0.02	13	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	16	-----	n.d.	n.d.	n.d.	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	17	-----	n.d.	n.d.	n.d.	992[2], 110[3], 100[4]	0	0%
Selenium, Total (ug/l)	1	17	-----	n.d.	n.d.	3	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	17	-----	n.d.	n.d.	1.2	15.9[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	17	-----	n.d.	n.d.	64	249[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	70	-----	n.d.	n.d.	0.09	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	70	-----	0.03	n.d.	1.47	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)***	0.05	70	-----	n.d.	n.d.	0.70	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	11					*****	-----	-----
Acetochlor, Total (ug/l)		11	-----	n.d.	n.d.	0.30	-----	-----	-----
Atrazine, Total (ug/l)		11	-----	n.d.	n.d.	0.40	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)		11	-----	n.d.	n.d.	0.10	390[2], 100[3]	0	0%
Profluralin, Total (ug/l)		4	-----	n.d.	n.d.	0.12	-----	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 305. Summary of water quality conditions monitored in the Missouri River at Decatur, Nebraska (i.e., site MORRR0691) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	89	25,895	27,100	11,500	42,400	-----	-----	-----
Water Temperature (C)	0.1	85	17.0	19.9	-0.1	29.8	29.0	1	1%
Dissolved Oxygen (mg/l)	0.1	85	9.2	8.6	6.4	14.9	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	85	96.3	97.4	60.8	118.1	-----	-----	-----
Specific Conductance (umho/cm)	1	85	718	721	489	891	2,000[5]	0	0%
pH (S.U.)	0.1	84	8.3	8.3	7.2	8.9	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential	1	32	387	389	287	516	-----	-----	-----
Alkalinity, Total (mg/l)	7	84	182	183	125	222	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	83	-----	0.09	n.d.	0.56	4.71 [1,2], 1.08 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	81	3.8	3.5	1.7	11.8	-----	-----	-----
Chloride (mg/l)	1	84	14	14	8	23	860[2], 230[3]	0	0%
Chemical Oxygen Demand (mg/l)	2	32	387	389	287	516	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	33	527	510	338	790	500[6]	18[6]	55%[6]
Hardness, Total (mg/l)	0.4	19	274	265	232	381	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	84	0.9	0.7	n.d.	5.0	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	83	0.94	0.69	n.d.	4.30	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	83	0.18	0.12	n.d.	1.10	-----	-----	-----
Suspended Solids, Total (mg/l)	4	84	87	40	n.d.	580	-----	-----	-----
Turbidity (NTU)	0.1	82	69.9	40.3	4.0	396.9	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	3	-----	n.d.	n.d.	n.d.	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	0.6	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	5	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	66	64	54	83	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	19	-----	n.d.	n.d.	n.d.	15.2[2], 0.48[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,315[2], 171[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	19	-----	n.d.	n.d.	n.d.	33.7[2], 20.6[3], 1,000[4]	0	0%
Lead, Dissolved (ug/l)	0.5	19	-----	n.d.	n.d.	n.d.	183[2], 7.15[3]	0	0%
Mercury, Dissolved (ug/l)	0.02	15	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	18	-----	n.d.	n.d.	n.d.	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,068[2], 119[3]	0	0%
Selenium, Total (ug/l)	1	19	-----	n.d.	n.d.	3	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	2	18.4[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	19	-----	n.d.	n.d.	68	268[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	74	-----	n.d.	n.d.	0.43	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	74	-----	0.10	n.d.	2.05	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)***	0.05	74	-----	n.d.	n.d.	0.68	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	11					*****	-----	-----
Acetochlor, Total (ug/l)			-----	n.d.	n.d.	0.15	-----	-----	-----
Atrazine, Total (ug/l)			-----	n.d.	n.d.	0.80	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)			-----	n.d.	n.d.	0.50	390[2], 100[3]	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 306. Summary of water quality conditions monitored in the Missouri River at Omaha, Nebraska (i.e., site MORRR0619) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	87	28,175	28,800	13,300	50,600	-----	-----	-----
Water Temperature (C)	0.1	86	16.8	18.9	-0.1	28.1	29.0	0	0%
Dissolved Oxygen (mg/l)	0.1	86	9.1	8.5	5.9	15.0	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	86	94.2	95.5	68.6	120.7	-----	-----	-----
Specific Conductance (umho/cm)	1	86	703	701	470	820	2,000[5]	0	0%
pH (S.U.)	0.1	85	8.3	8.3	6.9	9.4	≥6.5 & ≤9.0	1	1%
Oxidation-Reduction Potential	1	32	391	389	309	528	-----	-----	-----
Alkalinity, Total (mg/l)	7	85	184	185	81	250	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	84	-----	0.08	n.d.	0.69	4.71 [1,2], 1.15 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	83	4.0	3.5	2.3	11.9	-----	-----	-----
Chloride (mg/l)	1	84	15	14	7	84	860[2], 230[3]	0	0%
Chemical Oxygen Demand (mg/l)	2	85	19	13	n.d.	141	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	34	515	515	328	640	500[6]	24[6]	71%[6]
Hardness, Total (mg/l)	0.4	19	281	271	237	379	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	85	1.1	0.8	0.1	5.1	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	84	1.5	1.3	n.d.	5.4	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	84	0.28	0.17	0.03	2.30	-----	-----	-----
Suspended Solids, Total (mg/l)	4	85	175	68	13	1,932	-----	-----	-----
Turbidity (NTU)	0.1	84	143.5	57.3	4.0	1,798.0	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	-----	n.d.	n.d.	n.d.	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	2	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	5	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	85	84	66	106	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	19	-----	n.d.	n.d.	n.d.	15.2[2], 0.48[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,315[2], 171[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	19	-----	n.d.	n.d.	n.d.	33.7[2], 20.6[3], 1,000[4]	0	0%
Lead, Dissolved (ug/l)	0.5	19	-----	n.d.	n.d.	1	183[2], 7.15[3]	0	0%
Mercury, Dissolved (ug/l)	0.02	19	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	19	-----	n.d.	n.d.	0.02	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,068[2], 119[3]	0	0%
Selenium, Total (ug/l)	1	19	-----	n.d.	n.d.	4	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	1	18.4[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	19	-----	n.d.	n.d.	39	268[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	0.34	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	72	-----	0.09	n.d.	16.20	330[2], 12[3], 3[4]	0, 1, 2	0%, 1%, 3%
Metolachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	2.60	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	13					*****	-----	-----
Acetochlor, Total (ug/l)			-----	n.d.	n.d.	0.46	-----	-----	-----
Atrazine, Total (ug/l)			-----	n.d.	n.d.	1.00	330[2], 12[3], 3[4]	0	0%
Metolachlor, Total (ug/l)			-----	n.d.	n.d.	0.40	390[2], 100[3]	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 307. Summary of water quality conditions monitored in the Missouri River at Nebraska City, Nebraska (i.e., site MORRR0563) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	88	33,908	33,450	16,700	85,800	-----	-----	-----
Water Temperature (C)	0.1	87	17.2	18.8	-0.1	29.2	29.0	1	1%
Dissolved Oxygen (mg/l)	0.1	87	8.8	8.0	5.4	14.7	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	87	91.4	91.8	67.3	104.8	-----	-----	-----
Specific Conductance (umho/cm)	1	87	685	690	480	804	2,000[5]	0	0%
pH (S.U.)	0.1	87	8.3	8.3	7.4	8.8	≥6.5 & ≤9.0	1	1%
Oxidation-Reduction Potential	1	30	386	375	312	530	-----	-----	-----
Alkalinity, Total (mg/l)	7	86	182	184	104	242	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	85	-----	0.10	n.d.	0.82	4.71 [1,2], 1.16 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	84	4.1	3.7	2.0	11.6	-----	-----	-----
Chloride (mg/l)	1	86	23	22	8	39	860[2], 230[3]	0	0%
Chemical Oxygen Demand (mg/l)	2	86	23	16	n.d.	137	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	34	487	501	318	610	500[6]	17[6]	50%[6]
Hardness, Total (mg/l)	0.4	18	264	262	231	311	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	86	1.3	1.0	0.1	5.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	85	1.48	1.40	0.04	4.0	10[4], 100[5]	0	0%
Phosphorus, Total (mg/l)	0.01	85	0.40	0.26	0.07	2.90	-----	-----	-----
Suspended Solids, Total (mg/l)	4	86	223	99	4	1,952	-----	-----	-----
Turbidity (NTU)	0.1	85	214.7	73.9	4.7	2,688.0	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	4	-----	n.d.	n.d.	47	750[2], 87[3], 200[4]	0	0%
Antimony, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	n.d.	88[2], 30[3], 6[4]	0	0%
Arsenic, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	6	340[2], 16.7[3], 10[4]	0	0%
Barium, Dissolved (ug/l)	5	4	105	104	79	135	2,000[4]	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130[2], 5 3[3], 4[4]	0	0%
Cadmium, Dissolved (ug/l)	0.2	19	-----	n.d.	n.d.	n.d.	15.0[2], 0.48[3], 5[4]	0	0%
Chromium, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,303[2], 170[3], 100[4]	0	0%
Copper, Dissolved (ug/l)	2	19	-----	n.d.	n.d.	3	33.3[2], 20.4[3], 1,000[4]	0	0%
Lead, Dissolved (ug/l)	0.5	19	-----	n.d.	n.d.	n.d.	181[2], 7.1[3]	0	0%
Mercury, Dissolved (ug/l)	0.02	19	-----	n.d.	n.d.	n.d.	1.4[2]	0	0%
Mercury, Total (ug/l)	0.02	19	-----	n.d.	n.d.	0.03	0.77[3], 2[4]	0	0%
Nickel, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	5	1,058[2], 117[3]	0	0%
Selenium, Total (ug/l)	1	19	-----	n.d.	n.d.	4	20[2,5], 5[3], 50[4]	0	0%
Silver, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	2	18.1[2], 100[4]	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400[2], 6.3[3], 2[4]	0	0%
Zinc, Dissolved (ug/l)	5	19	-----	n.d.	n.d.	72	265[2,3], 5,000[4]	0	0%
Alachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	0.30	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)***	0.05	73	-----	0.15	n.d.	13.20	330[2], 12[3], 3[4]	0, 1, 4	0%, 1%, 5%
Metolachlor, Total (ug/l)***	0.05	73	-----	n.d.	n.d.	2.34	390[2], 100[3]	0	0%
Pesticide Scan (ug/l)****	0.05	13					*****	-----	-----
Acetochlor, Total (ug/l)			-----	n.d.	n.d.	0.54	-----	-----	-----
Alachlor, Total (ug/l)			-----	n.d.	n.d.	0.10	760[2], 76[3], 2[4]	0	0%
Atrazine, Total (ug/l)			-----	n.d.	n.d.	6.6	330[2], 12[3], 3[4]	0, 0, 1	0%, 0%, 8%
Metolachlor, Total (ug/l)			-----	n.d.	n.d.	2.80	390[2], 100[3]	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 308. Summary of water quality conditions monitored in the Missouri River at Rulo, Nebraska (i.e., site MORRR0498) during the 5-year period 2003 through 2007.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Streamflow (cfs)	1	87	34,924	33,550	17,500	72,700	-----	-----	-----
Water Temperature (C)	0.1	86	18.0	19.9	-0.1	30.6	29.0	3	3%
Dissolved Oxygen (mg/l)	0.1	86	8.8	8.2	5.0	14.6	≥ 5.0	0	0%
Dissolved Oxygen (% Sat.)	0.1	86	92.4	92.5	66.0	111.8	-----	-----	-----
Specific Conductance (umho/cm)	1	86	688	692	502	796	2,000(5)	0	0%
pH (S.U.)	0.1	86	8.2	8.3	7.4	8.8	≥6.5 & ≤9.0	1	1%
Oxidation-Reduction Potential	1	32	383	375	303	538	-----	-----	-----
Alkalinity, Total (mg/l)	7	85	181	182	105	242	≥ 20	0	0%
Ammonia, Total (mg/l)	0.01	84	-----	0.08	n.d.	0.83	4.71 (1,2), 1.08 (1,3)	0	0%
Carbon, Total Organic (mg/l)	0.05	83	3.8	3.5	1.4	10.5	-----	-----	-----
Chloride (mg/l)	1	84	21	20	7	35	860(2), 230(3)	0	0%
Chemical Oxygen Demand (mg/l)	2	85	19	15	n.d.	114	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	33	495	496	320	640	500(6)	14(6)	42%(6)
Hardness, Total (mg/l)	0.4	18	263	257	231	331	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	85	1.2	1.0	0.4	5.4	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	84	1.66	1.50	0.03	4.30	10(4), 100(5)	0	0%
Phosphorus, Total (mg/l)	0.01	84	0.37	0.28	0.08	1.70	-----	-----	-----
Suspended Solids, Total (mg/l)	4	85	199	117	14	1,656	-----	-----	-----
Turbidity (NTU)	0.1	83	160.9	78.0	3.9	1,512.0	-----	-----	-----
Aluminum, Dissolved (mg/l)	25	3	-----	n.d.	n.d.	56	750(2), 87(3), 200(4)	0	0%
Antimony, Dissolved (ug/l)	0.5	5	-----	n.d.	n.d.	1.0	88(2), 30(3), 6(4)	0	0%
Arsenic, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	7	340(2), 16.7(3), 10(4)	0	0%
Barium, Dissolved (ug/l)	5	4	104	102	76	136	2,000(4)	0	0%
Beryllium, Dissolved (ug/l)	2	5	-----	n.d.	n.d.	n.d.	130(2), 5 3(3), 4(4)	0	0%
Cadmium, Dissolved (ug/l)	0.2	19	-----	n.d.	n.d.	n.d.	14.8(2), 0.47(3), 5(4)	0	0%
Chromium, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,283(2), 167(3), 100(4)	0	0%
Copper, Dissolved (ug/l)	2	19	-----	n.d.	n.d.	30	32.7(2), 20.1(3), 1,000(4)	0, 1, 0	0%, 5%, 0%
Lead, Dissolved (ug/l)	0.5	19	-----	n.d.	n.d.	n.d.	177(2), 6.9(3)	0	0%
Mercury, Dissolved (ug/l)	0.02	19	-----	n.d.	n.d.	n.d.	1.4(2)	0	0%
Mercury, Total (ug/l)	0.02	19	-----	n.d.	n.d.	0.02	0.77(3), 2(4)	0	0%
Nickel, Dissolved (ug/l)	10	19	-----	n.d.	n.d.	n.d.	1,040(2), 116(3)	0	0%
Selenium, Total (ug/l)	1	19	-----	n.d.	n.d.	6	20(2,5), 5(3), 50(4)	0	0%
Silver, Dissolved (ug/l)	1	19	-----	n.d.	n.d.	2	17.5(2), 100(4)	0	0%
Thallium, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	1,400(2), 6.3(3), 2(4)	0	0%
Zinc, Dissolved (ug/l)	5	19	-----	n.d.	n.d.	41	261(2,3), 5,000(4)	0	0%
Alachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	0.23	760(2), 76(3), 2(4)	0	0%
Atrazine, Total (ug/l)***	0.05	72	-----	0.13	n.d.	4.36	330(2), 12(3), 3(4)	0, 0, 2	0%, 0%, 3%
Metolachlor, Total (ug/l)***	0.05	72	-----	n.d.	n.d.	2.01	390(2), 100(3)	0	0%
Pesticide Scan (ug/l)****	0.05						*****	-----	-----
Acetochlor, Total (ug/l)			-----	n.d.	n.d.	0.30	-----	-----	-----
Atrazine, Total (ug/l)			-----	n.d.	n.d.	6	330(2), 12(3), 3(4)	0, 0, 1	0%, 0%, 8%
Metolachlor, Total (ug/l)			-----	n.d.	n.d.	2.20	390(2), 100(3)	0	0%

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values.
(2) Acute criterion for aquatic life.
(3) Chronic criterion for aquatic life.
(4) Human health criterion for surface waters.
(5) Agricultural criterion for surface waters.
(6) The criterion for total dissolved solids is listed by the State of Nebraska to protect the beneficial use of public drinking water. Where the natural background level is greater than these criteria, the State of Nebraska states that the background level is to be used in place of the criteria. The elevated total dissolved solids and iron levels are believed indicative of natural background conditions and are not considered a water quality standards "violation".

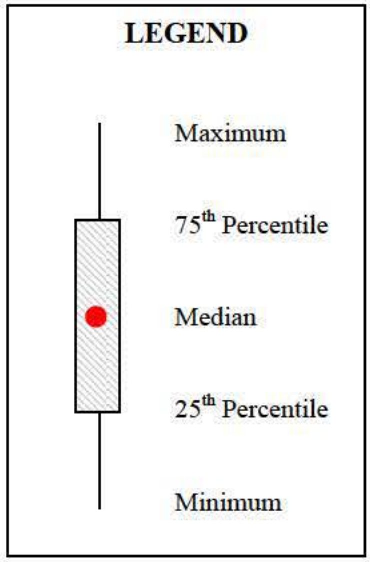
Note: South Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

Plate 309. Distribution plots (i.e., box plots) for selected parameters monitored at locations along the Missouri River from Gavins Point Dam to Rulo, Nebraska during the 5-year period of 2003 through 2007.



Note: Monitoring location refers to the River Mile (RM) along the Missouri River where the monitoring site was located.

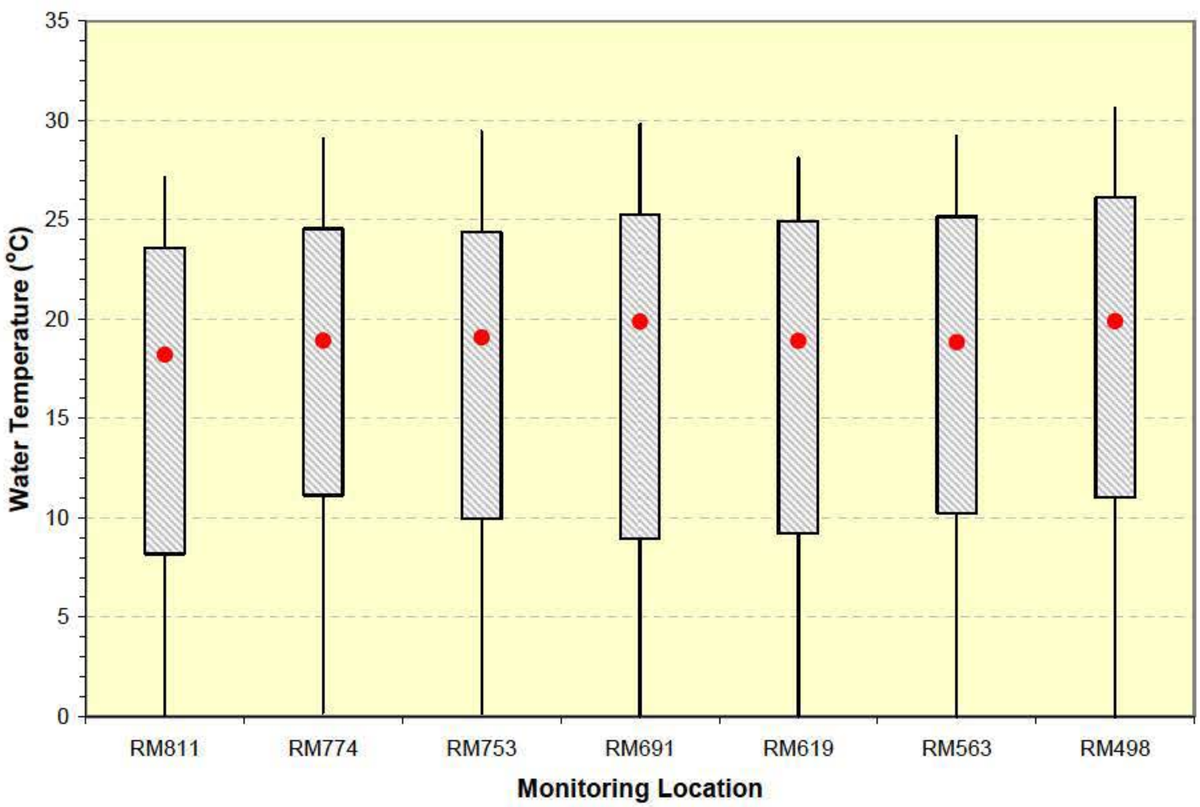
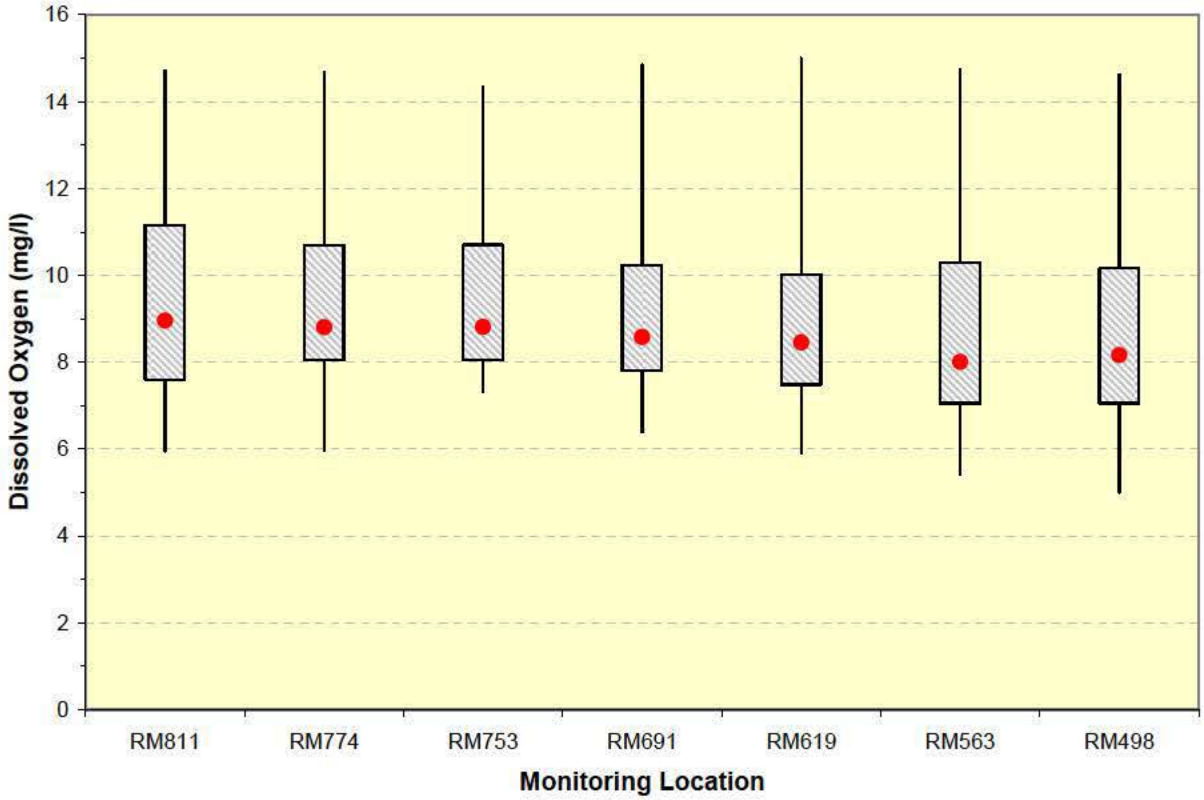


Plate 309. (Continued).



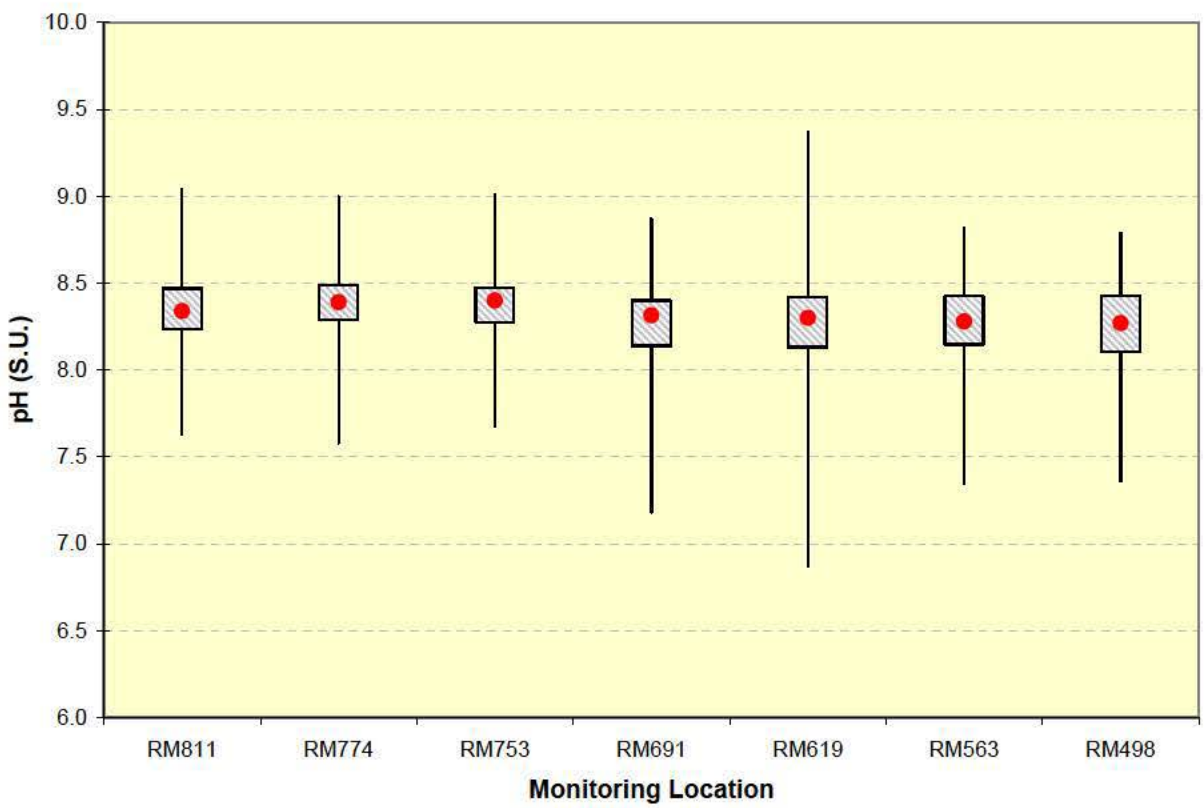
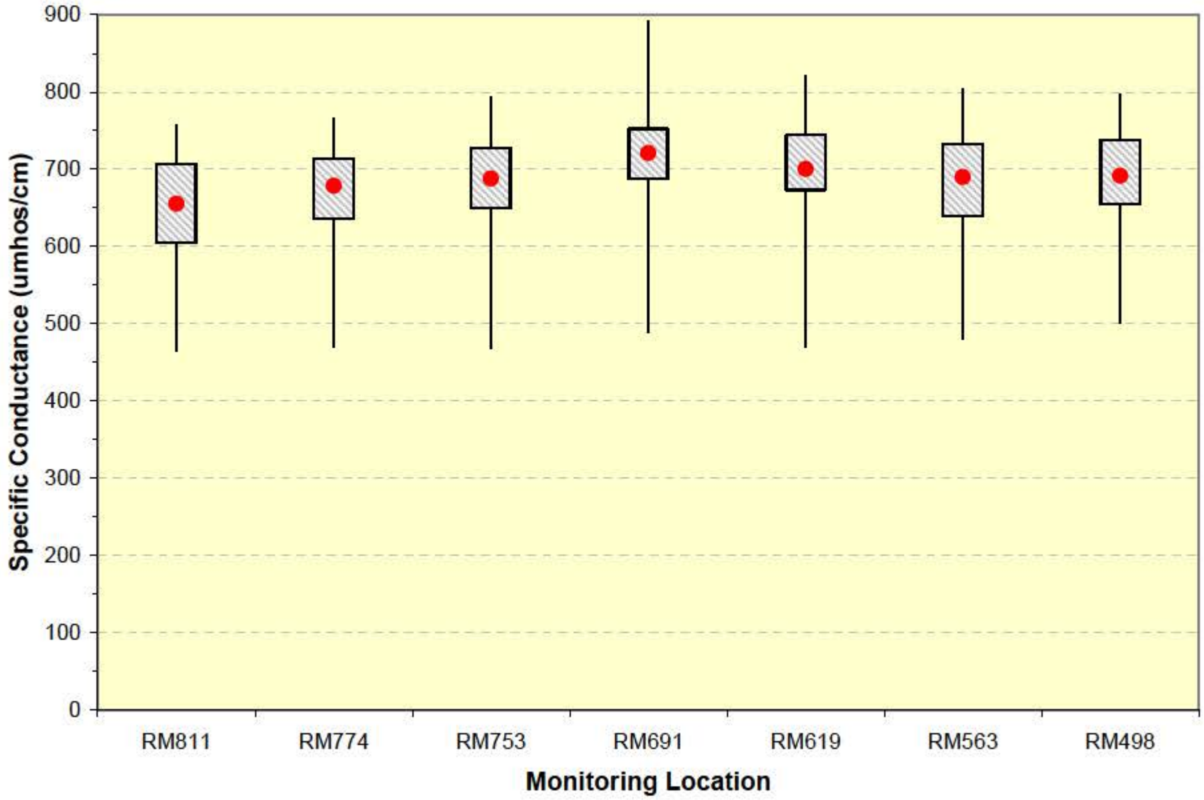


Plate 309. (Continued).



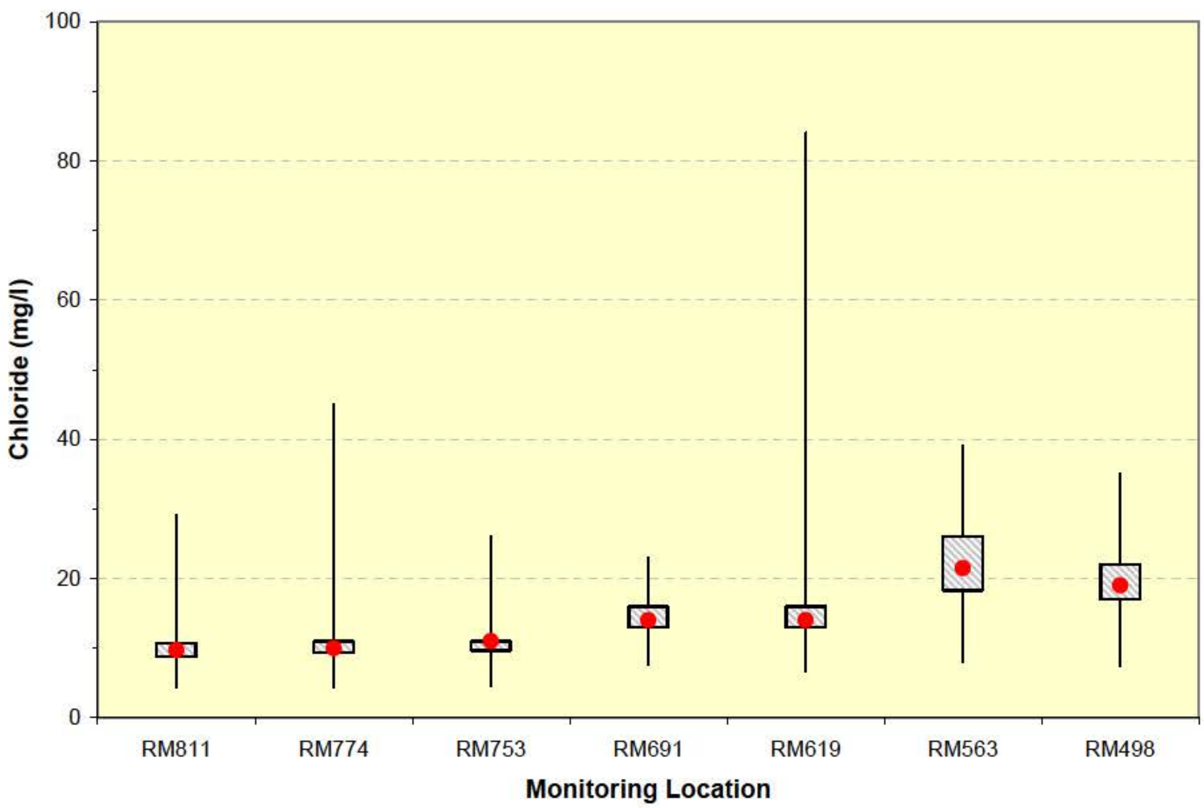
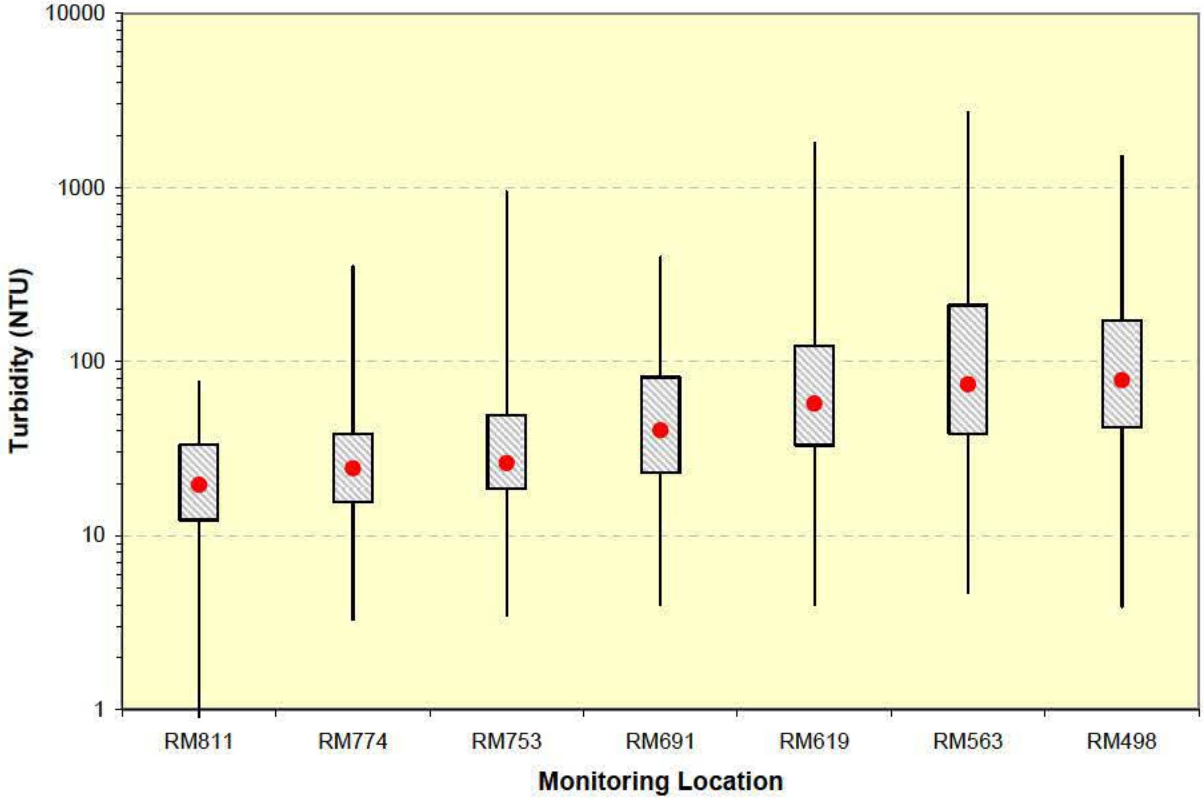


Plate 309. (Continued).



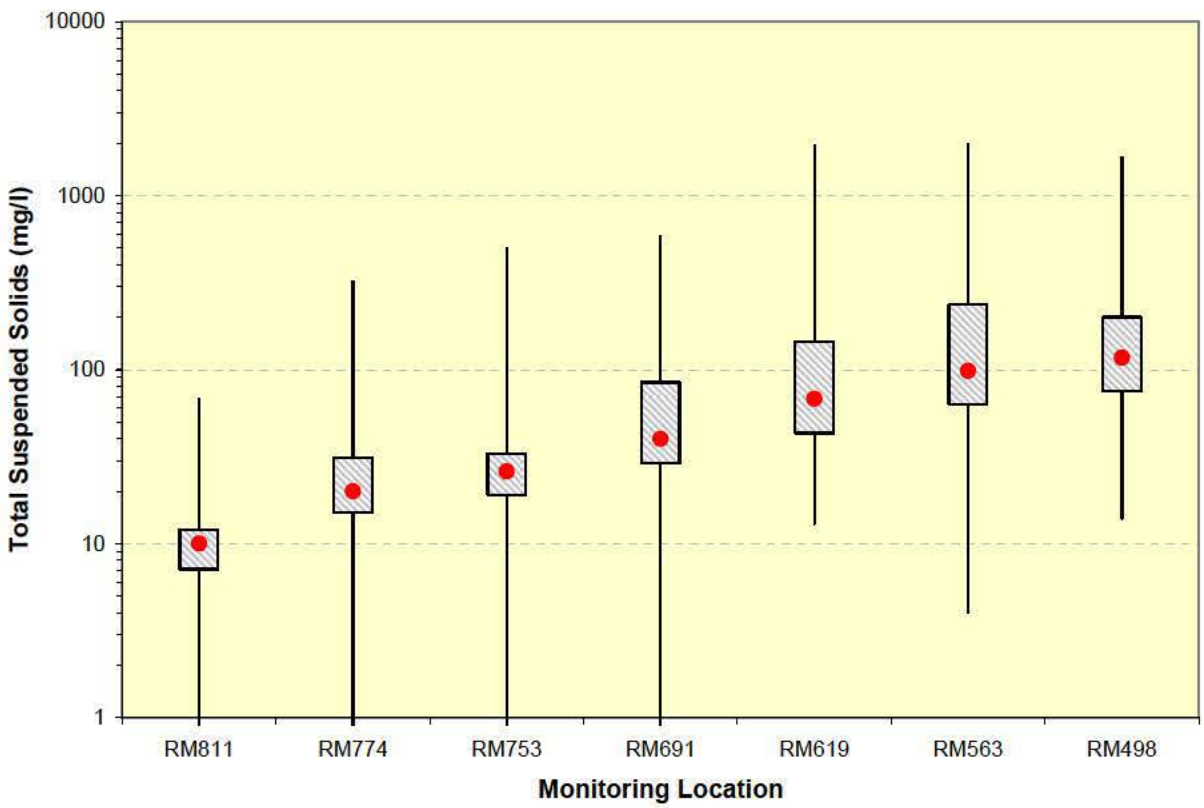
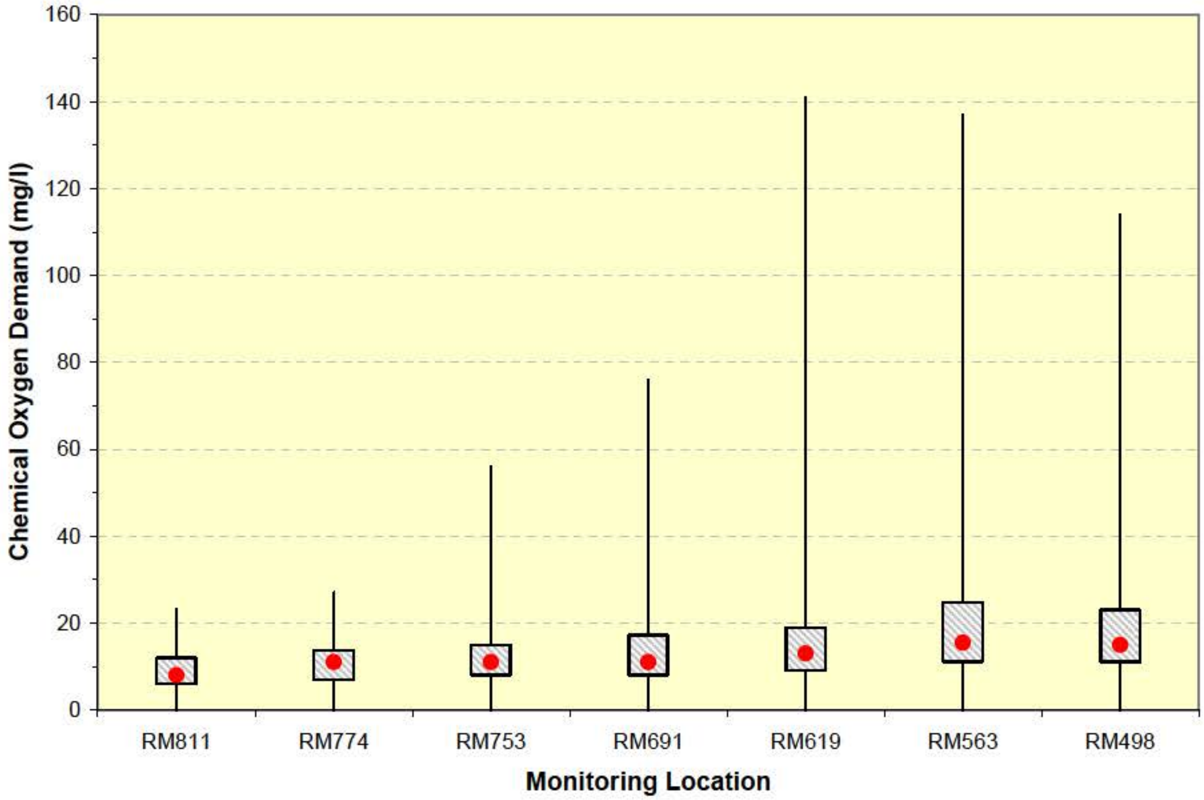


Plate 309. (Continued).



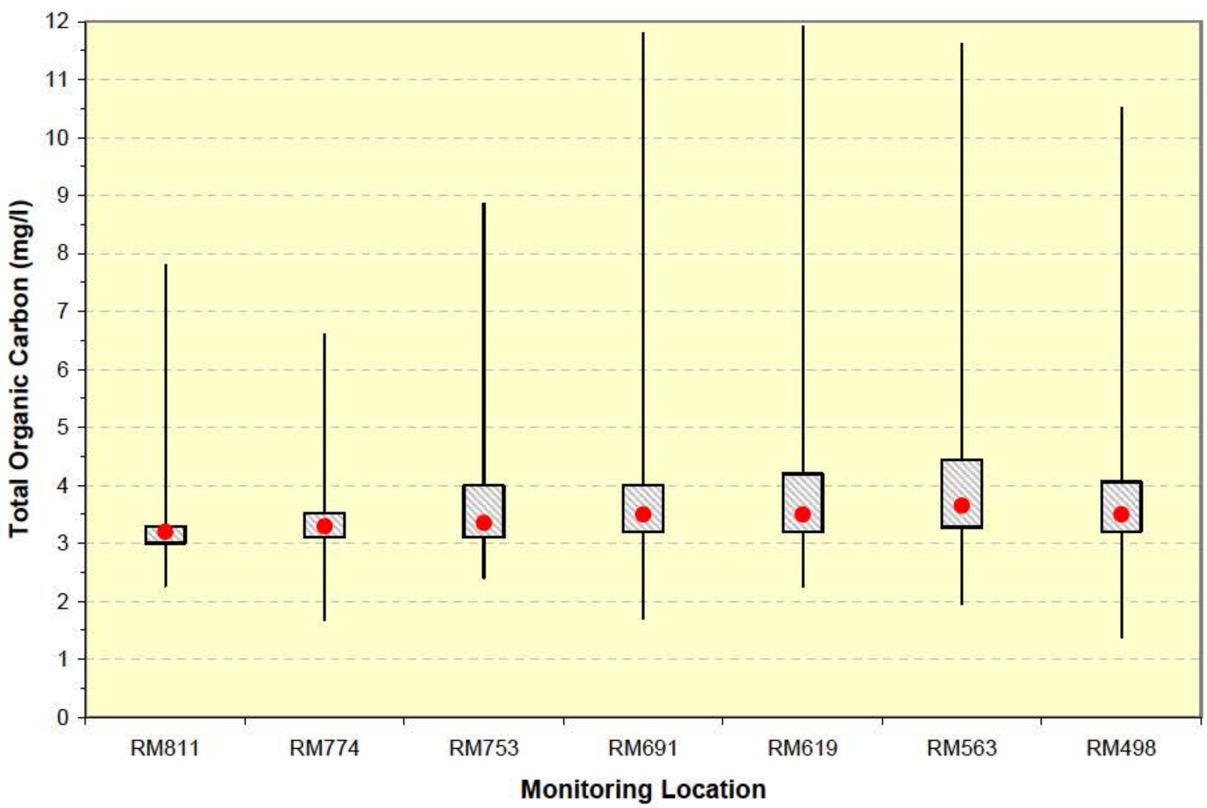
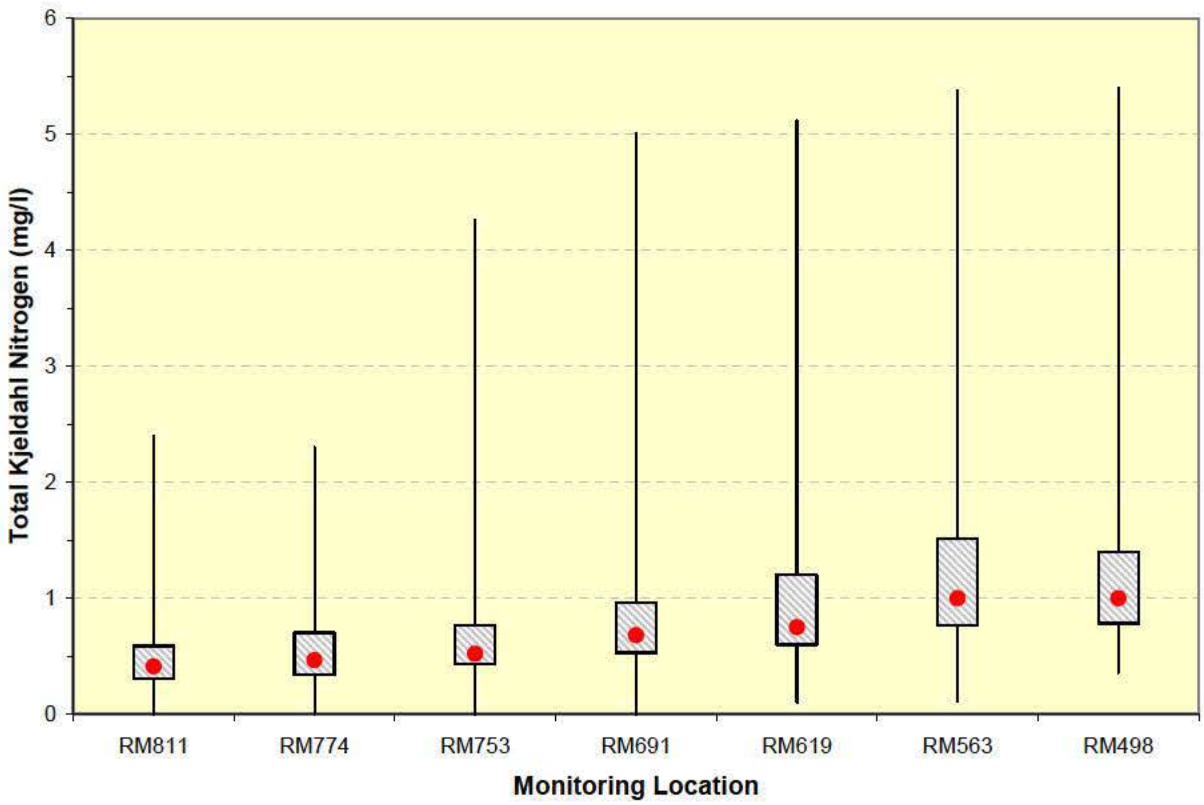


Plate 309. (Continued).



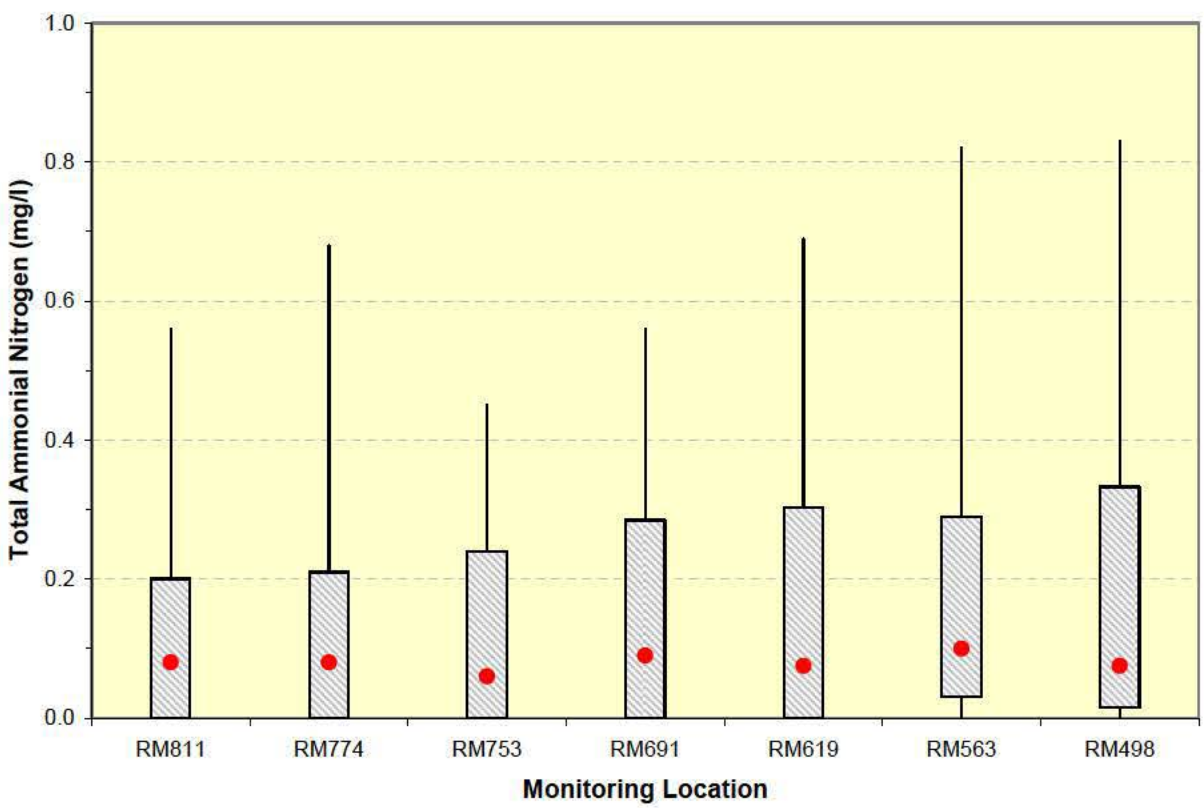
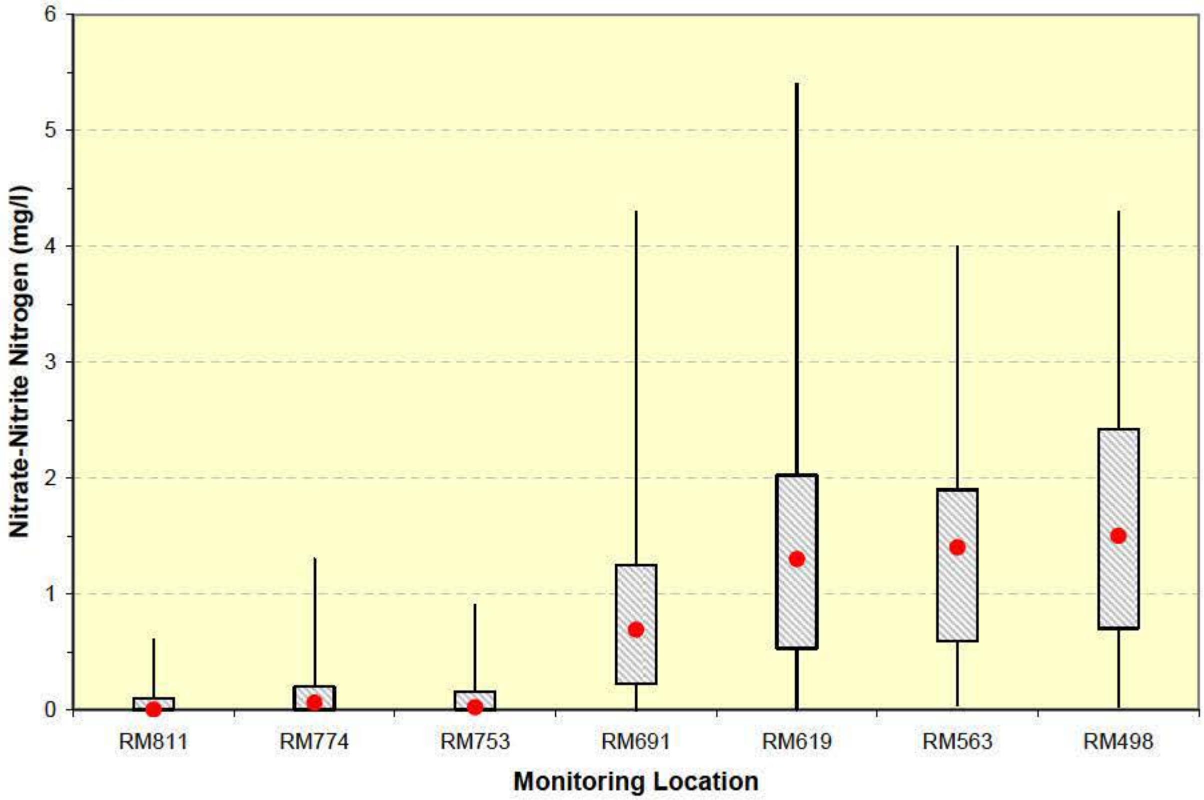


Plate 309. (Continued).



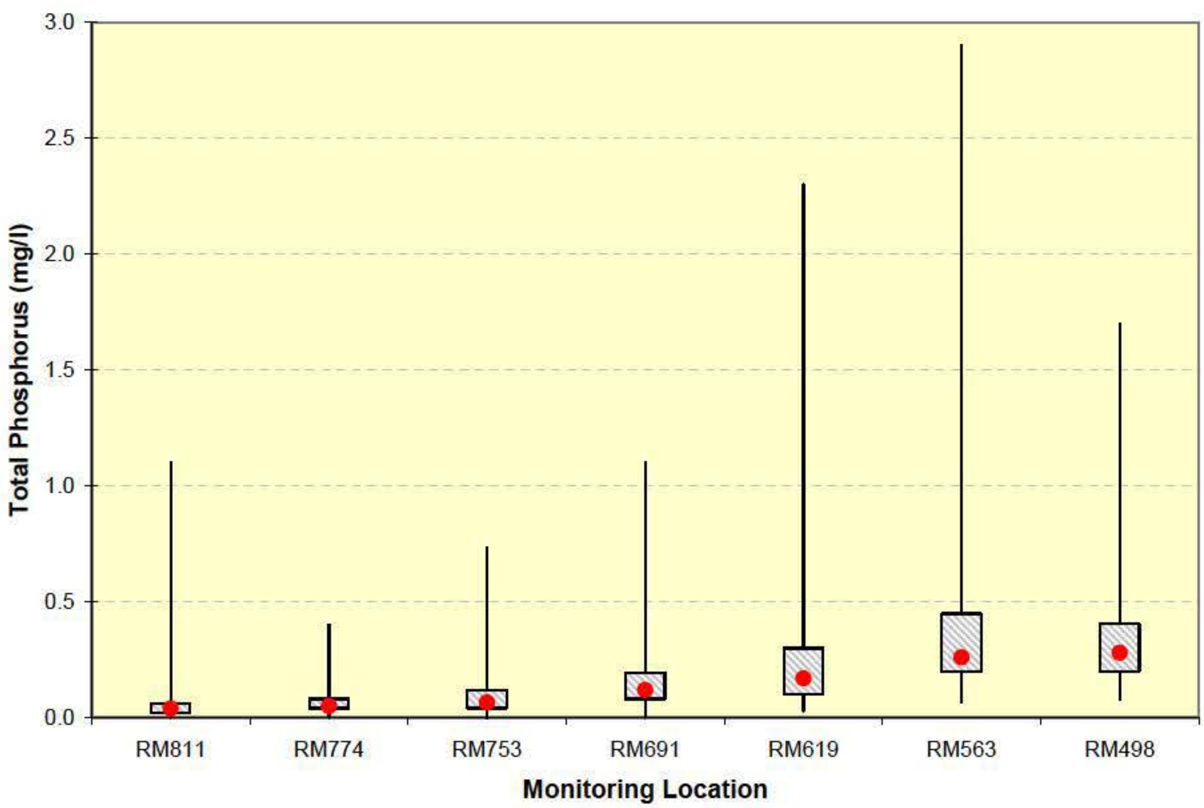
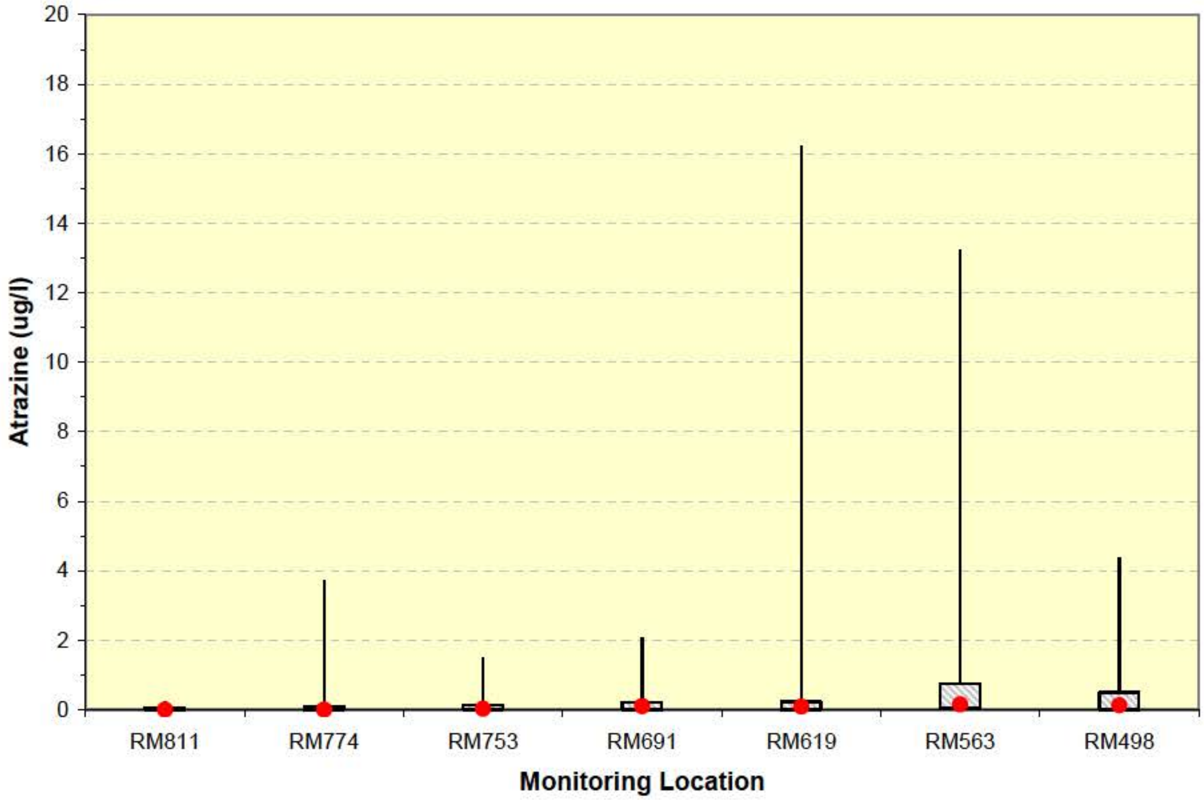


Plate 309. (Continued).



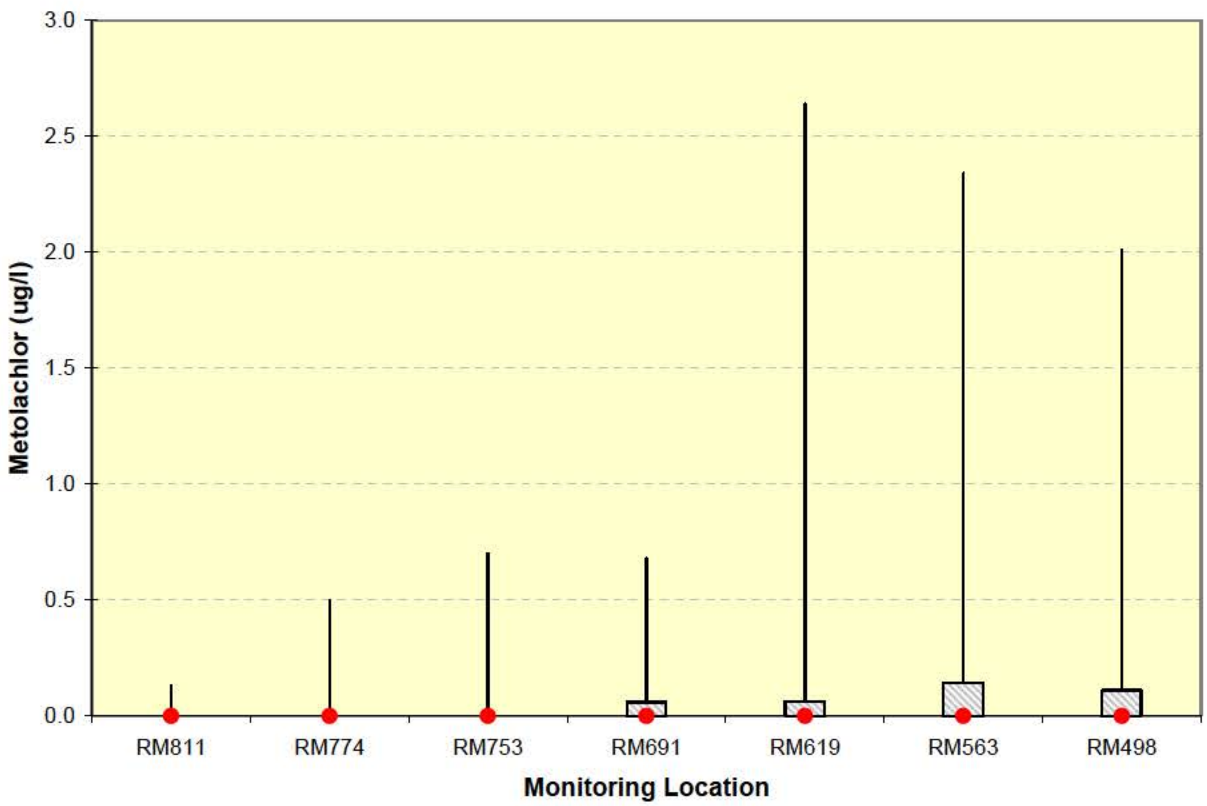


Plate 310. Summary of monthly (May through September) water quality conditions monitored in Lake Audubon (i.e., site AUDLKND1) during 2002 and 2006.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation	1	4	1846.9	1847.0	1846.8	1847.0	-----	-----	-----
Water Temperature (C)	0.1	91	18.3	18.3	10.4	15.5	29.4	0	0%
Dissolved Oxygen (mg/l)	0.1	91	8.1	8.3	1.7	9.8	≥ 5.0	4	4%
Dissolved Oxygen (% Sat.)	0.1	91	89.8	94.3	19.1	103.2	-----	-----	-----
Specific Conductance (umho/cm)	1	91	891	911	228	969	-----	-----	-----
pH (S.U.)	0.1	91	8.5	8.5	7.8	8.8	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential (mV)	1	67	379	325	315	477	-----	-----	-----
Secchi Depth (in)	1	7	88	67	48	130	-----	-----	-----
Alkalinity, Total (mg/l)	7	12	210	121	170	223	-----	-----	-----
Ammonia, Total (mg/l)	0.01	8	-----	0.02	n.d.	0.08	2.14 [1,2], 0.79 [1,3]	0	0%
Carbon, Total Organic (mg/l)	0.05	12	5.0	5.0	4.6	5.8	-----	-----	-----
Chlorophyll *a* (ug/l) - Lab Determined	1	4	-----	1.5	n.d.	3	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	8	631	635	590	670	-----	-----	-----
Hardness, Total (mg/l)	0.4	6	265	272	245	276	-----	-----	-----
Iron, Dissolved (ug/l)	40	8	-----	n.d.	n.d.	40	-----	-----	-----
Iron, Total (ug/l)	40	8	209	208	80	383	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	12	-----	0.2	n.d.	0.7	-----	-----	-----
Manganese, Dissolved (ug/l)	1	8	2.5	2.5	1	4	-----	-----	-----
Manganese, Total (ug/l)	1	8	13	11	4	24	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	12	-----	n.d.	n.d.	0.10	-----	-----	-----
Phosphorus, Dissolved (mg/l)	0.01	8	-----	n.d.	n.d.	0.01	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	12	0.07	0.03	n.d.	0.35	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	12	-----	n.d.	n.d.	n.d.	-----	-----	-----
Sulfate (mg/l)	1	8	321	320	310	330	-----	-----	-----
Suspended Solids, Total (mg/l)	4	12	-----	n.d.	n.d.	8	-----	-----	-----
Antimony, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	6[5]	0	0%
Arsenic, Dissolved (ug/l)	1	2	-----	n.d.	n.d.	3.	340[2], 150[3], 50[6]	0	0%
Beryllium, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	4[6]	0	0%
Cadmium, Dissolved (ug/l)	0.2	2	-----	n.d.	n.d.	n.d.	14.0[2], 5.4[3], 5[6]	0	0%
Chromium, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	4,092[2], 196[3], 100[6]	0	0%
Copper, Dissolved (ug/l)	2	2	-----	n.d.	n.d.	n.d.	35.9[2], 21.9[3], 1,000[6]	0	0%
Lead, Dissolved (ug/l)	0.5	2	-----	n.d.	n.d.	n.d.	292[2], 11.4[3], 15[6]	0	0%
Nickel, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	1,094[2], 121[3], 100[6]	0	0%
Selenium, Total (ug/l)	1	2	-----	n.d.	n.d.	n.d.	20[2], 5[3], 50[6]	0	0%
Silver, Dissolved (ug/l)	1	2	-----	n.d.	n.d.	n.d.	14.7	0	0%
Zinc, Dissolved (ug/l)	10	2	-----	n.d.	n.d.	n.d.	280[2,3], 9,100[6]	0	0%
Pesticide Scan (ug/l)***	0.05	1	-----	n.d.	n.d.	n.d.	****	0	0%
Microcystins	0.2	4	-----	n.d.	n.d.	n.d.	-----	-----	-----

n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** [1] Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values of 8.5 and 18.3 respectively.

[2] Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)

[3] Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)

[6] Human health criterion for surface waters.

Note: North Dakota's WQS criteria for metals are based on total recoverable, most analyzed metal concentrations were dissolved. Listed criteria are given for comparison and were calculated using the median hardness of 272 mg/l.

*** The pesticide scan includes: acetochlor, benfluralin, butylate, chlorpyrifos, cyanazine, cycloate, EPTC, hexazinone, isopropalin, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, profluralin, prometon, propachlor, propazine, simazine, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

**** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

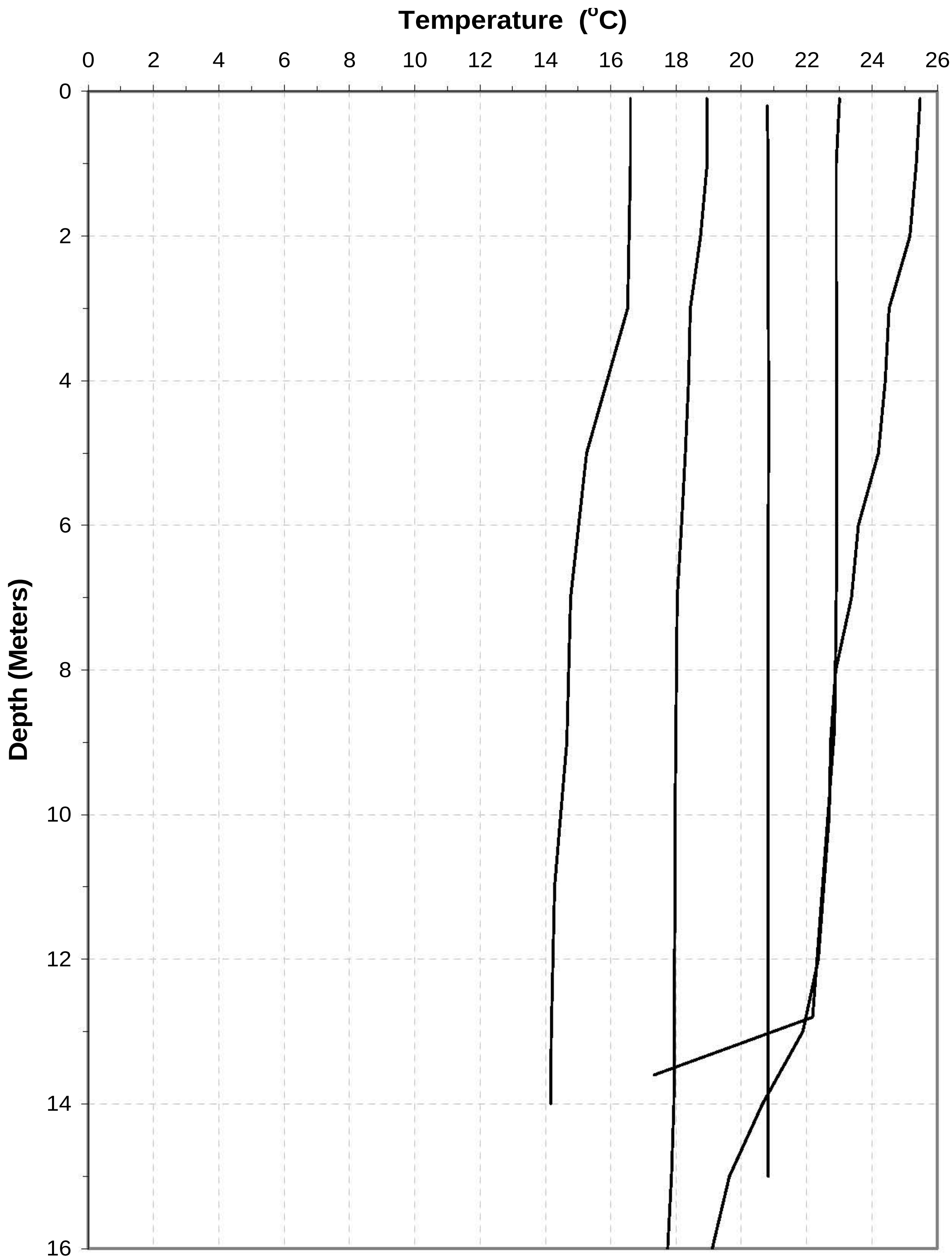


Plate 311. Temperature depth profiles for Lake Audubon generated from data collected at the near-dam, deepwater ambient monitoring site during the summer months of 2002 and 2006.

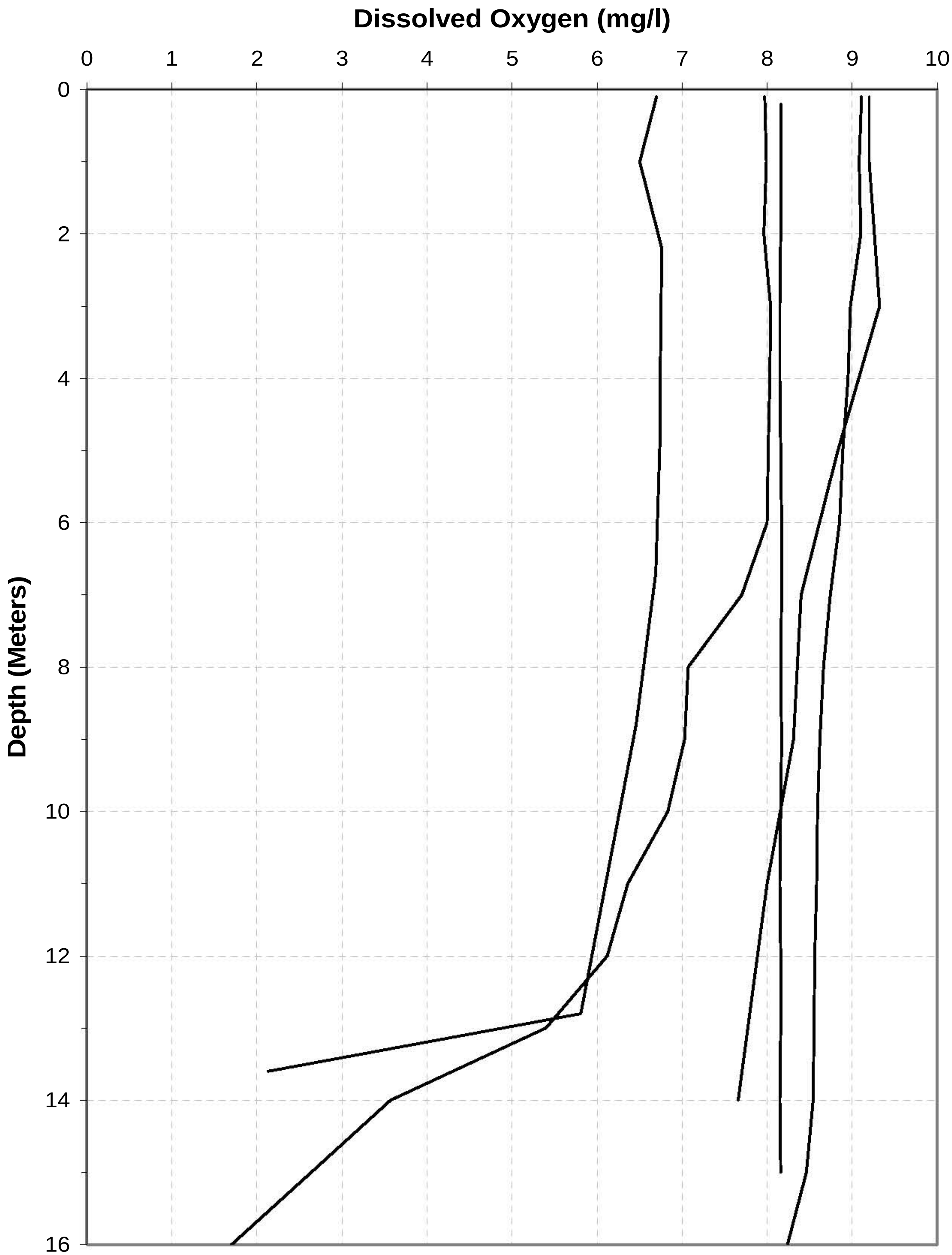


Plate 312. Dissolved oxygen depth profiles for Lake Audubon generated from data collected at the near-dam, deepwater ambient monitoring site during the summer months of 2002 and 2006.

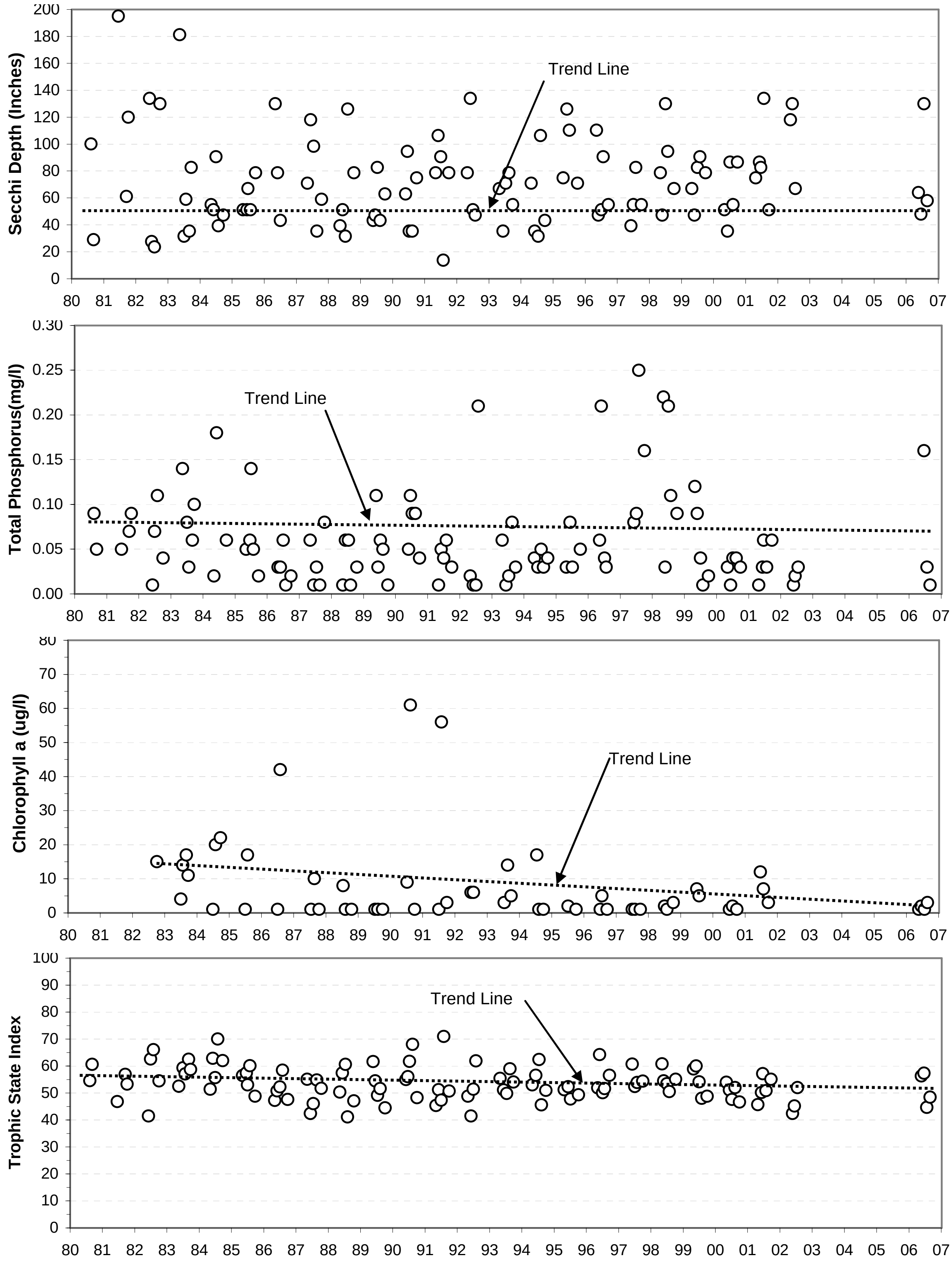


Plate 313. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Lake Audubon at the near-dam, ambient site over the 27-year period of 1980 to 2006.

Plate 314. Summary of monthly (May through September) water quality conditions monitored in Lake Yankton (i.e., site YAKLKND1) during 2002, 2003, and 2006.

Parameter	Monitoring Results						Water Quality Standards Attainment		
	Detection Limit	No. of Obs.	Mean*	Median	Min.	Max.	State WQS Criteria**	No. of WQS Exceedences	Percent WQS Exceedence
Pool Elevation	1	5	1167.5	1167.5	1167.2	1167.7	-----	-----	-----
Water Temperature (C)	0.1	78	19.6	19.1	13.9	26.6	29	0	0%
Dissolved Oxygen (mg/l)	0.1	78	5.6	7.1	0.2	10.3	≥ 6.0 ≥ 5.0	31 28	40% 36%
Dissolved Oxygen (% Sat.)	0.1	78	64.4	85.1	2.0	127.3	-----	-----	-----
Specific Conductance (umho/cm)	1	78	1,044	1,064	874	1,136	-----	-----	-----
pH (S.U.)	0.1	78	7.8	7.8	7.0	8.7	≥6.5 & ≤9.0	0	0%
Oxidation-Reduction Potential (mV)	1	35	336	341	31	443	-----	-----	-----
Secchi Depth (in)	1	15	39	36	12	72	-----	-----	-----
Alkalinity, Total (mg/l)	7	27	195	200	140	238	-----	-----	-----
Ammonia, Total (mg/l)	0.01	17	-----	0.10	n.d.	0.46	12.1(1,2), 2.4 (1,3)	0	0%
Carbon, Total Organic (mg/l)	0.05	21	3.4	3.3	2.4	5.3	-----	-----	-----
Chlorophyll *a* (ug/l) - Lab Determined	1	13	-----	4	n.d.	68	-----	-----	-----
Dissolved Solids, Total (mg/l)	5	10	714	705	680	790	-----	-----	-----
Hardness, Total (mg/l)	0.4	10	444	449	414	485	-----	-----	-----
Iron, Dissolved (ug/l)	40	10	-----	n.d.	n.d.	50	-----	-----	-----
Iron, Total (ug/l)	40	10	140	131	60	238	-----	-----	-----
Kjeldahl N, Total (mg/l)	0.1	27	-----	0.3	n.d.	1.0	-----	-----	-----
Manganese, Dissolved (ug/l)	1	10	1,407	285	7	6,620	-----	-----	-----
Manganese, Total (ug/l)	1	10	1,628	497	207	6,808	-----	-----	-----
Nitrate-Nitrite N, Total (mg/l)	0.02	27	-----	n.d.	n.d.	0.06	10(6)	0	0%
Phosphorus, Dissolved (mg/l)	0.01	10	-----	n.d.	n.d.	0.02	-----	-----	-----
Phosphorus, Total (mg/l)	0.01	27	0.05	0.03	n.d.	0.22	-----	-----	-----
Phosphorus-Ortho, Dissolved (mg/l)	0.01	27	-----	n.d.	n.d.	0.15	-----	-----	-----
Sulfate (mg/l)	1	8	395	400	340	420	875(6)	0	0%
Suspended Solids, Total (mg/l)	4	27	-----	6	n.d.	17	158(2), 90(3)	0	0%
Antimony, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	88(2), 30(3)	0	0%
Arsenic, Dissolved (ug/l)	1	4	-----	n.d.	n.d.	3.	340(2), 16.7(3)	0	0%
Beryllium, Dissolved (ug/l)	2	4	-----	n.d.	n.d.	n.d.	130(2), 5.3(3)	0	0%
Cadmium, Dissolved (ug/l)	0.2	4	-----	n.d.	n.d.	n.d.	25.4(2), 0.7(3)	0	0%
Chromium, Dissolved (ug/l)	10	4	-----	n.d.	n.d.	n.d.	2,026(2), 263(3)	0	0%
Copper, Dissolved (ug/l)	2	4	-----	n.d.	n.d.	n.d.	55.3(2), 32.3(3)	0	0%
Lead, Dissolved (ug/l)	0.5	4	-----	n.d.	n.d.	n.d.	316(2), 12.3(3)	0	0%
Nickel, Dissolved (ug/l)	10	4	-----	n.d.	n.d.	n.d.	1,668(2), 185(3)	0	0%
Selenium, Total (ug/l)	1	4	-----	n.d.	n.d.	n.d.	20(2), 5(3)	0	0%
Silver, Dissolved (ug/l)	1	4	-----	n.d.	n.d.	n.d.	45.7	0	0%
Zinc, Dissolved (ug/l)	10	3	-----	n.d.	n.d.	n.d.	422(2,3)	0	0%
Microcystins	0.2	5	-----	n.d.	n.d.	n.d.	-----	-----	-----
Alachlor, Total (ug/l)***	0.05	7	-----	n.d.	n.d.	0.06	760(2), 76(3)	0	0%
Atrazine, Total (ug/l)***	0.05	7	-----	0.07	n.d.	1.07	330(2), 12(3)	0	0%
Metolachlor, Total (ug/l)***	0.05	7	-----	n.d.	n.d.	0.06	390(2), 100(3)	0	0%
Pesticide Scan (ug/l)****	0.05	2					*****	-----	-----
Atrazine, Total (ug/l)		2	-----	14.8	n.d.	29.6	330(2), 12(3)	1	50%
Chlorpyrifos, Total (ug/l)		2	-----	7.35	n.d.	14.7	0.083(2), 0.041(3)	1	50%

Note: Where numeric water quality standards criteria are present for both the State of Nebraska and South Dakota, the Nebraska criteria are given.
n.d. = Not detected.

* Nondetect values set to 0 to calculate mean. If 20% or more of observations were nondetects, mean is not reported. The mean value reported for pH is an arithmetic mean based on measured values (i.e , log conversion of logarithmic pH values was not done to calculate mean).

** (1) Total ammonia criteria pH and temperature dependent. Criteria listed are for median pH and temperature values of 7.8 and 19.1 respectively.
(2) Acute criterion for aquatic life. (Note: Several metals acute criteria for aquatic life are hardness based.)
(3) Chronic criterion for aquatic life. (Note: Several metal chronic criteria for aquatic life are hardness based.)
(6) Public Drinking Water Supply.
Note: Criteria are hardness based -- listed criteria were calculated using the median hardness of 449 mg/l.

*** Immunoassay analysis.

**** The pesticide scan (GCMS) includes: acetochlor, alachlor, ametryn, atrazine, benfluralin, bromacil, butachlor, butylate, chlorpyrifos, cyanazine, cycloate, deethylatrazine, deisopropylatrazine, dimethenamid, diuron, EPTC, ethalfluralin, fonofos, hexazinone, isophenphos, isopropalin, metolachlor, metribuzin, molinate, oxadiazon, oxyfluorfen, pebulate, pendimethalin, phorate, profluralin, prometon, prometryn, propachlor, propazine, simazine, terbufos, triallate, trifluralin, and vernolate. Individual pesticides were not detected unless listed under pesticide scan.

***** Some pesticides don't have water quality standards criteria defined, and for those pesticides that have criteria, the criteria vary.

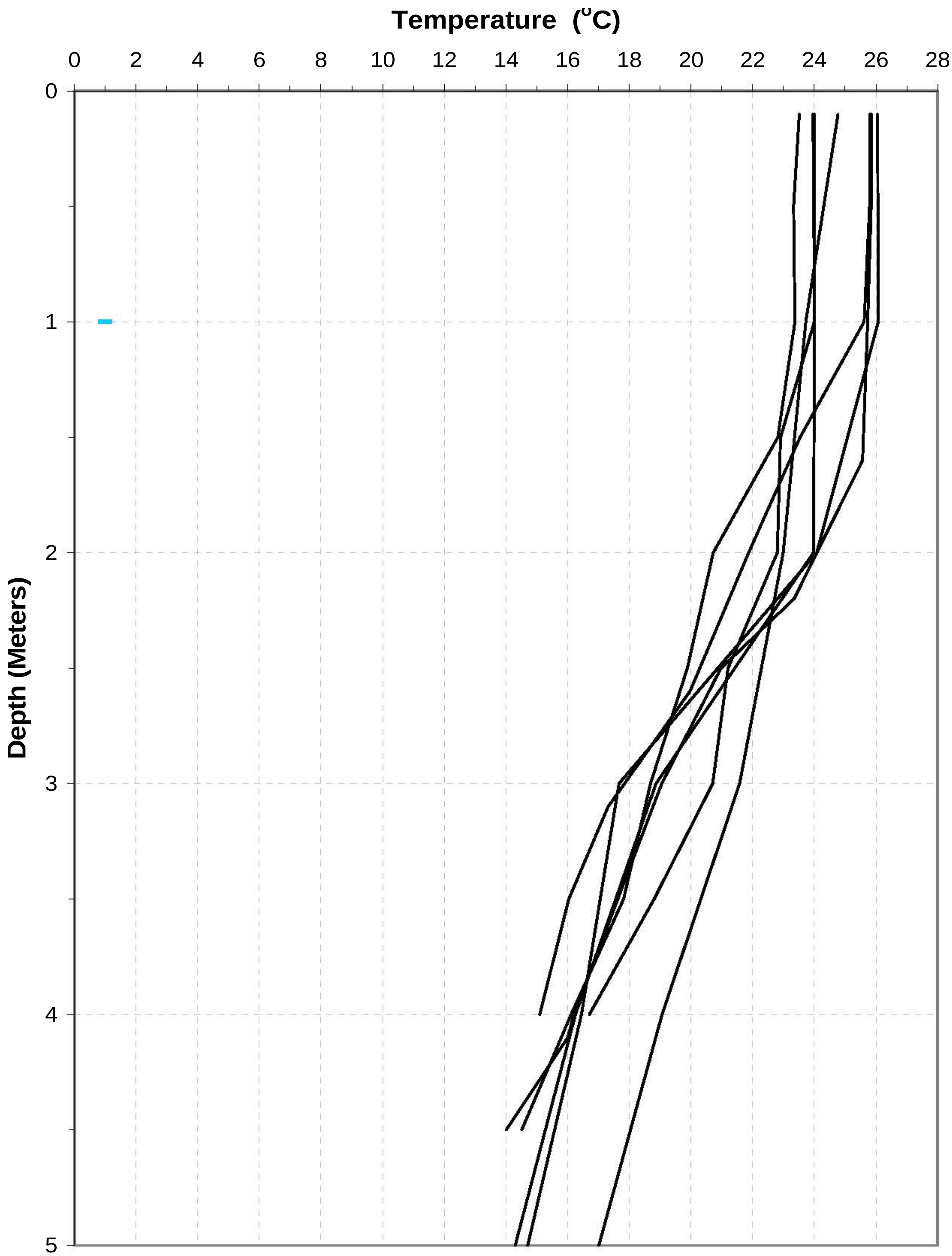


Plate 315. Temperature depth profiles for Lake Yankton generated from data collected at the deepwater ambient monitoring site during the summer months of 2002 and 2006.

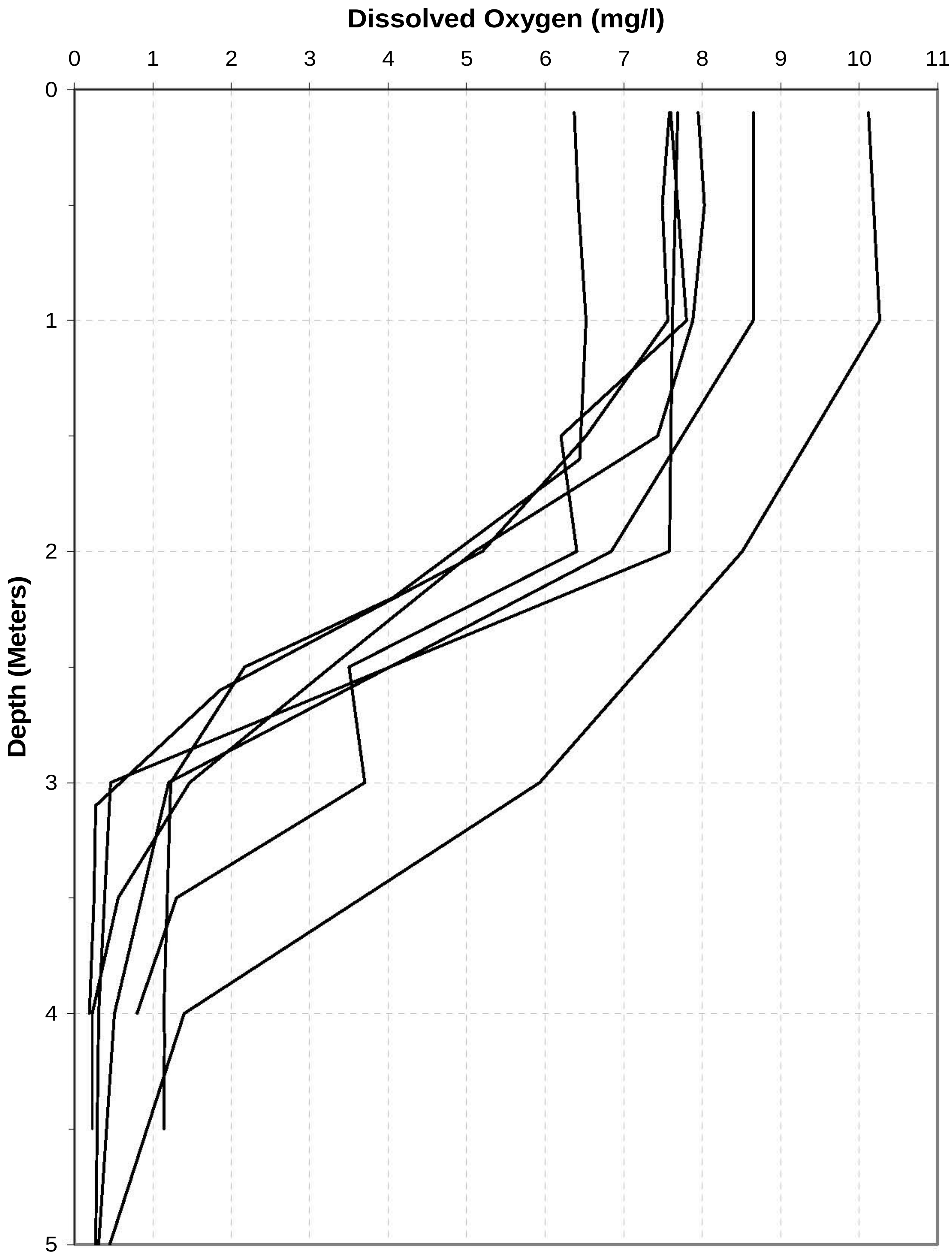


Plate 316. Dissolved oxygen depth profiles for Lake Yankton generated from data collected at the deepwater ambient monitoring site during the summer months of 2002 and 2006.

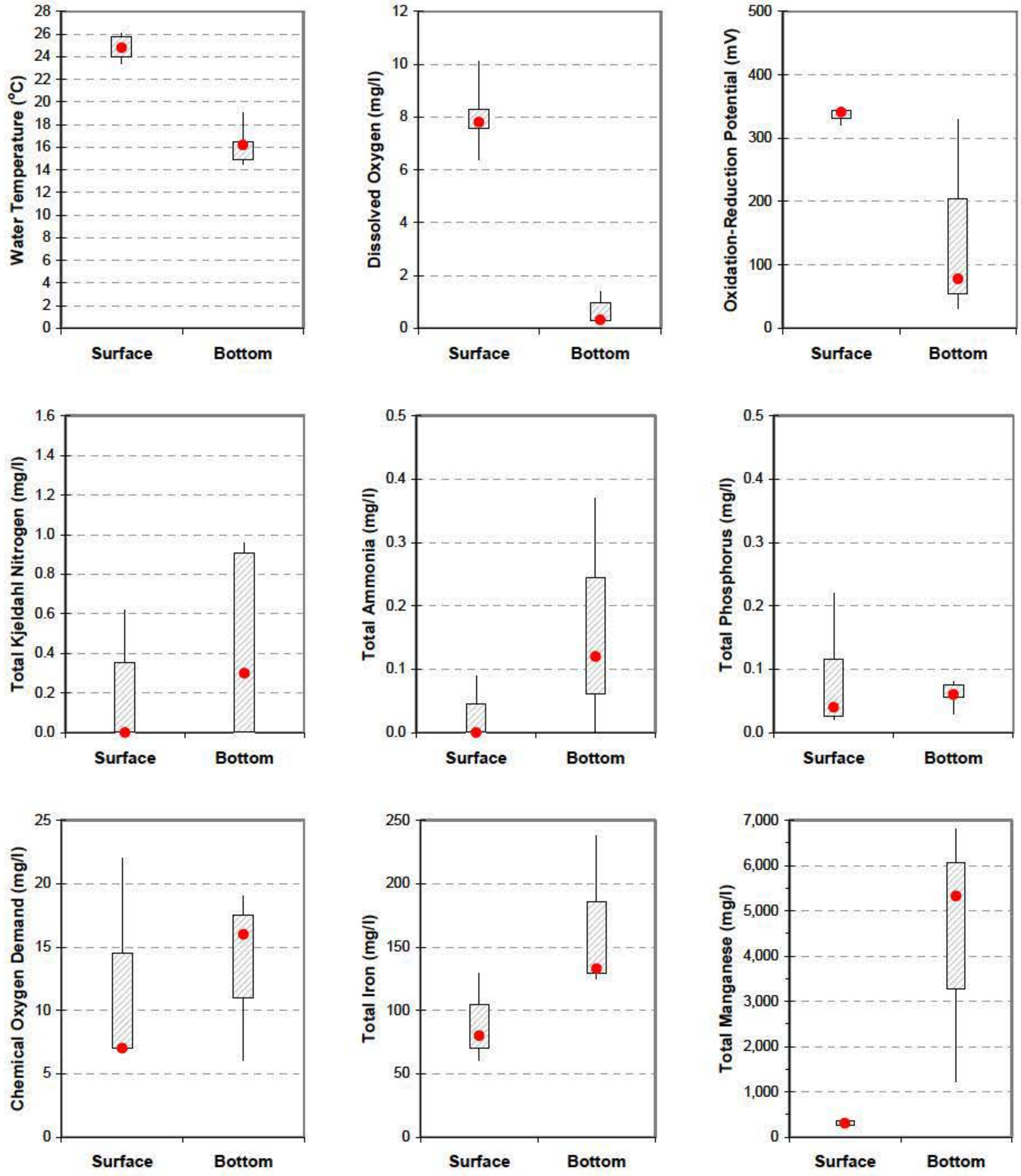


Plate 317. Box plots comparing surface and bottom water temperature, dissolved oxygen, oxidation-reduction potential, total Kjeldahl nitrogen, total ammonia nitrogen, total phosphorus, chemical oxygen demand, total iron, and total manganese measured in Lake Yankton at site YAKLKND1 during the summer months of 2002 and 2006. (Box plots display minimum, 25th percentile, 75th percentile, and maximum. Median value is indicated by the red dot. Non-overlapping interquartile ranges of the adjacent box plots indicate a significant difference between surface and bottom measurements.)

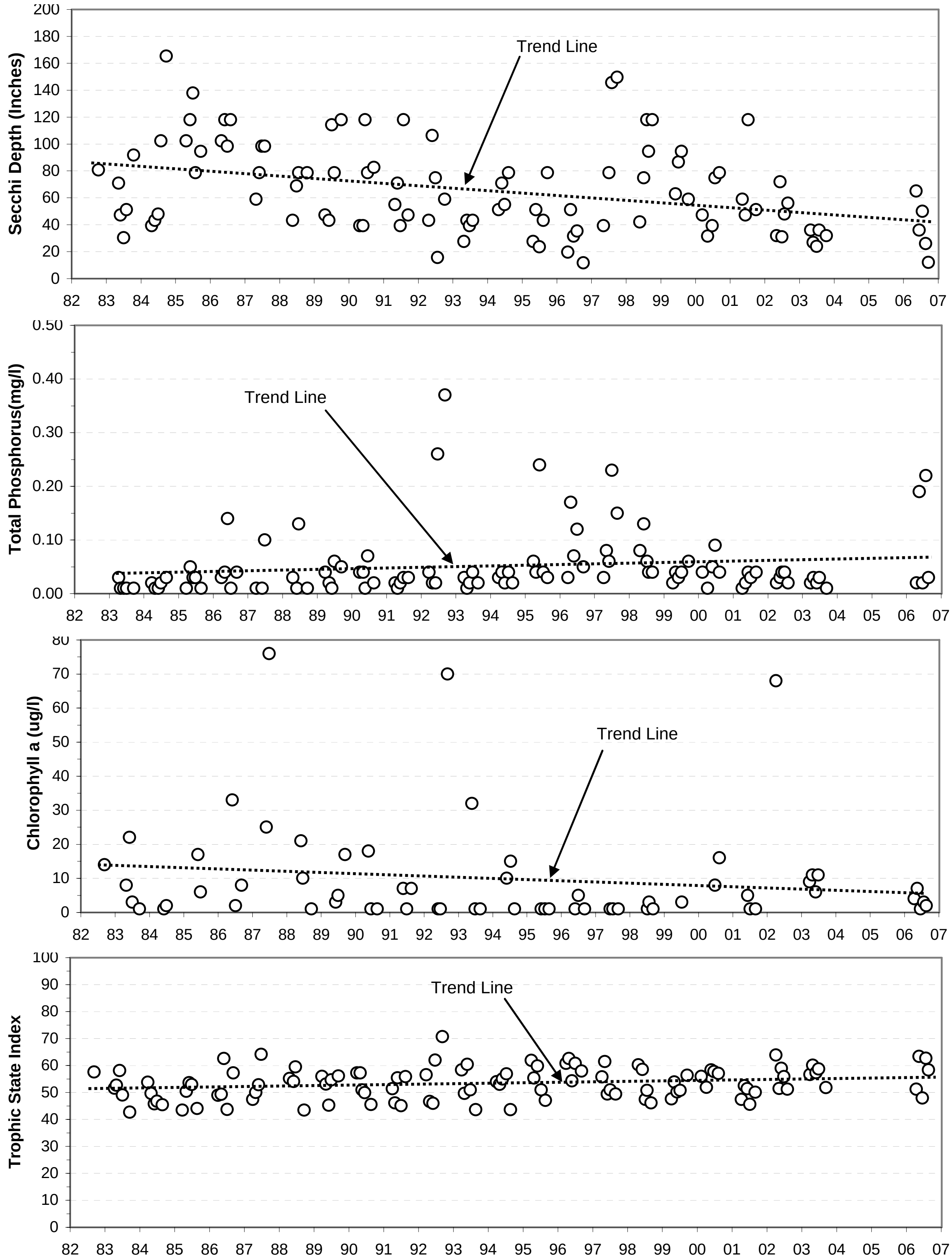


Plate 318. Historic trends for Secchi depth, total phosphorus, chlorophyll *a*, and Trophic State Index (TSI) monitored in Lake Audubon at the near-dam, ambient site over the 27-year period of 1980 to 2006.